MECHANISMS in Modern Engineering Design

A Handbook
for Engineers,
Designers and Inventors

by IVAN I. ARTOBOLEVSKY, D. Sc. (Eng.)
Member, USSR Academy of Sciences

Volume I

Lever Mechanisms

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by Nicholas Weinstein

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PREFACE

One of the problems facing the modern theory of mechanisms is the study and systematization of the huge inheritance accumulated in mechanical engineering practice and consisting of numerous mechanisms applied in various machines, instruments and devices.

An analysis of this data and its classification into the various kinds of mechanisms have shown that their systematization should be broken down into two stages. The first is the compilation of collections of mechanisms employed in all branches of the engineering industries. The next stage consists of collections compiled for different branches, such as mechanisms for precision instruments, mechanisms of machine tools, mechanisms of aircraft engines.

The need of such systematically compiled data is evidently very great because information on the various kinds of mechanisms that have been devised is scattered, for the most part, among diverse reference sources: textbooks, monographs, journals, patent applications, etc. This data is difficult to use because some of the editions may be more or less unique, and because the data does not, as a rule, contain the necessary descriptions, classification and system that would enable a mechanism to be quickly selected for some definite purpose specified by a designer.

It is of equal importance, in the author's opinion, to meet the needs of inventors. A vast number of inventions are being made in the USSR and abroad, and their quantity is increasing year by year. Inventors require convenient handbooks where they can readily find elementary schemes of mechanisms that can accomplish the forms of motion needed for the designs they propose.

To meet this demand, in 1947-52 the author compiled a four-volume work called *Mechanisms* which was published (in Russian) by the USSR Academy of Sciences. This work contains drawings and descriptions of 4000 mechanisms and includes those made up of hydraulic, pneumatic and electrical devices, as well as purely mechanical systems. This four-volume work has long been out of print and, judging from letters received by the author from a great many engineers, designers, technicians and inventors, a new edition is more than timely. To meet this demand the author has prepared the present completely revised and considerably supplemented edition. This work is to comprise five volumes. The first two volumes contain drawings and descriptions of lever mechanisms, i.e. mechanisms based on kinematic chains made up of lower pairs. The third volume is devoted to gear mechanisms. The fourth volume contains cam, friction and flexible-link mechanisms. The final volume is to deal with hydraulic, pneumatic and electrical mechanisms.

The present work, *Lever Mechanisms*, in two volumes, deals with mechanisms having lower pairs and contains drawings and descriptions of 2288 mechanisms. The author has mainly selected general-purpose mechanisms that find application in many branches of industry. Certain special-purpose mechanisms employed mainly in single branches of industry have also been included. The reason is that they may prove of interest to other branches of industry. These mechanisms have been assigned a separate subgroup: mechanisms of functional devices.

In this work the author has taken into consideration all the suggestions and remarks made by the readers of the earlier edition. One such suggestion concerns the addition of subgroups dealing with kinematic pairs and movable joints. Any mechanism comprises kinematic chains consisting of these elements. Consequently, it is of prime importance for designers to correctly establish the structure of the mechanism they are dealing with and to select the necessary combination of kinematic pairs. The kinematic pairs and movable joints are illustrated by drawings which provide a more pictorial representation than the conventional symbols used for kinematic diagrams. This should facilitate the designing process. Descriptions of mechanisms of especially complicated structure have been expanded in comparison to the earlier edition. This was done by the well-founded request of certain readers who found difficulty in understanding some structures of mechanisms that were too briefly dealt with previously.

Wherever necessary the author has supplemented the description with analytical relationships of the parameters of the mechanisms, as well as with their kinematic characteristics: displacements, velocities, paths, etc.

In working on the present edition the author gave much attention to the problems of systematizing and classifying the mechanisms. The structures of the mechanisms were carefully checked. All errors found in the reference material, some quite essential ones, have been corrected. In all doubtful cases, investigations were conducted on the parameters of the mechanisms with the aim of checking their properties against those claimed by the sources from which they were taken (this refers, in the main, to guiding mechanisms, dwell mechanisms, etc.).

The author's aim was to produce a handbook for engineers and technicians of all ranks, as well as inventors, and not only for experts in the field of mechanisms theory. Hence, he has conscientiously avoided special terminology and notation intelligible only to experts in this line. The author has tried to use the simplest possible drawings furnished with the simplest possible descriptions that should be understandable even to persons without any special engineering training.

In collecting the mechanisms the author used extensive references, some in Russian and some in other languages. These references are not listed here since they would require too much space and could render no essential service to the reader unless supplemented by a great many additional references and notes. As concerns the overwhelming majority of the mechanisms given here, it is extremely difficult to establish priority with respect to whom they were first proposed and/or described by. Exceptions have been made only for mechanisms whose designers are generally known. In these cases, the designer's or inventor's name has been given to the mechanism.

As far as practicable, the author tried to keep the drawing of each mechanism the same as is given in the source where it was found, changes being made only whenever necessary to clear up the structure and kinematics. This means that many drawings from the older reference sources may lack some details and components that would certainly be found in up-to-date designs, but which were not in use at the time when the given mechanism was proposed (shapes of pistons and cylinders, shape of cross-head castings, etc.).

The author is grateful to all those who sent him their suggestions and remarks and, in some cases, even diagrams of new mechanisms. For various reasons, however, not all of these suggestions could be used in this new edition. The author also wishes to express his indebtedness to the personnel of the laboratories he heads in the Institute of Mechanical Engineering for their extremely valuable aid in preparing this edition for print. He is likewise grateful to the Department of the Theory of Mechanisms and Machines of the USSR Polytechnical Correspondence Institute for the numerous comments and suggestions which were made in reviewing the manuscript.

Particular thanks are due to V. A. Zinovyev and N. I. Rozalskaya for their participation and assistance in publishing this work.

Please send all comments on shortcomings of this handbook, reports on errors found by the readers and suggestions for future changes and supplementary data to I. I. Artobolevsky, Institute of Mechanical Engineering, Ul. Griboyedova 4, Moscow 101830, U.S.S.R. They will be appreciated.

I. I. Artobolevsky

INTRODUCTION

1. Schematical Representation of the Mechanisms

For the purpose of clarity and to provide more convenience in using this handbook, the mechanisms have been depicted by a system of arbitrary schematical representations resembling ordinary design drawings. This has been done in spite of the fact that a system of graphical symbols has long been standardized in the USSR and other countries for representing links and elements of kinematic pairs. Here they are shown as bars, slide blocks, slotted links, etc. which have only approximately the proportions they would have in a constructionally accurate design drawing.

Furthermore, it was found that in most cases it would be necessary to reject an exact representation of components of the mechanism as they would be shown in design drawings. Such a representation would require the introduction of additional details which may be of importance to the design but which would overload the drawing of the mechanism, making it difficult to perceive the form of motion the given mechanism is devised to produce.

This particularly concerns components of frames, bearings, uprights, thrust rings, bushings, etc. Neither were certain conventions, widely applied in modern design drawings, made use of in all cases with respect to sections, projections, hatching, threads, dashed lines, etc. Stricter observance of these conventions would have made the kinematics and structure of the mechanisms less readily understandable to the reader.

Thus, for instance, teeth are shown in the drawings of certain lever and gear mechanisms, in others only the addendum and dedendum circles are shown. Screw threads may be differently shown, depending upon the function of the mechanism, extra dash lines are not shown, etc.

The cross sections of pivots of turning pairs are shown hatched or solid black when the pivots are secured in the base or upright of the mechanism. This makes it more convenient to analyse the structure and kinematics of the illustrated mechanisms.

Arrows have been shown alongside certain links of the mechanisms to illustrate the form of their motion: straight arrows for translational and circular arrows for turning motions; double straight arrows for reciprocating and double circular arrows for oscillating motions.

The links are denoted by Arabian numerals, the pivots of the various pairs by capital letters, and the axes of turning and translational pairs by the small letters x, y and z. Additional components or necessary supplementary dimensions are denoted by small letters.

In cases when the form of motion of a mechanism depends upon the proportions between the sizes of its links (straight-line mechanisms, dwell mechanisms, etc.), these proportions are indicated in the description as a function of the size of the driving link.

With respect to all other mechanisms for which the dimensions of the links are not specified, it must be borne in mind that in using the handbook dimensions cannot be taken directly from the drawings. They must, of course, first be analysed and proportioned to suit the particular design they are intended for. The present handbook gives only the kinematic scheme without investigating the displacements of the links, their possible interference, extreme positions, etc.

2. Descriptions of the Mechanisms

Each drawing of a mechanism is accompanied by a concise description. These descriptions have not been unified because the mechanisms are of different degrees of complexity and, consequently, some require a more extensive explanation to make their operation clear while others require much less explanation since their function is quite understandable from the drawing alone. The "patent-office" type of description, called the "specification", has been resorted to for the more complex mechanisms. Here the numbers of the links are indicated, as well as the nature of their constraints which provides the required law of motion of the driven links. Only typical features, determining the principal function of the mechanism, are indicated for simpler mechanisms. Not even the service function is given for the very simplest mechanisms. It is clear from the drawing. Here the description consists of only a few remarks concerning either the kinematics or the design of the mechanism. The only link numbers mentioned in the description are those required to provide a clear idea about the nature of the motion of the mechanism. Certain mechanisms are illustrated in the same manner as they were given in the reference sources. Piston-type mechanisms are shown, for example, with pistons, cylinders and other typical components.

3. System of Classification Used

Two systems of classifying mechanisms have been found convenient for designers: classification according to structural and constructional features and classification according to the service function. The optimal solution, in our opinion, is a classification that unites these two trends. An attempt at such a classification has been made in this work.

The most difficult problem was to decide which system of classification to accept as the basic one. After detailed investigation, structural classification was decided upon. If the handbook had been based on the service function system, a great many extensively applied general-purpose mechanisms (slider-crank, four-bar linkage, etc.) would have had to be included in almost each group of mechanisms accomplishing one or another function. Thus, the same mechanism would be repeated in several groups. A more orderly system for a handbook of general-purpose mechanisms is a classification based on structural and constructional features. But a second classification, according to service function, should be given parallel with and linked to the first and basic classification.

It proves more expedient to base specialized mechanisms handbooks on the service function classification, also providing a parallel structural classification.

The classification of mechanisms, worked out for this handbook and based on the structural-constructional and functional features, is as follows. All mechanisms have been divided into twelve main groups, each group being further divided into subgroups. Each group has an index consisting of two capital letters abbreviating the group name, and each subgroup has an index of one, two or three letters also derived from its name.

This classification is given in Summary Table 1 (pages 17 through 31). Evidently, the groups and subgroups of the table could be expanded by adding certain kinds of mechanisms that were not included in the present work.

Classification of mechanisms according to their service function is auxiliary in this handbook since it is mainly general-purpose mechanisms that have been systematized, i.e. mechanisms used for performing a great diversity of operations in various branches of mechanical engineering. Consequently, in distributing the mechanisms according to their purpose, we have limited ourselves to singling out only certain subgroups which have common functional aims. Our main goal was to render aid to designers in solving the problems put to them; to enable them to quickly find a number of feasible solutions of various structural form.

Table 2 (pages 32 through 41) lists the mechanisms in accordance with their service function.

In some cases, mechanisms with the same type of structure have been included in different subgroups because of the different functions they perform. Slider-crank mechanisms, for example, can be found in the subgroup of piston machine mechanisms and in the subgroup of mechanisms for mathematical operations.

Some subgroups contain mechanisms that are of the same structure but each of which are of interest in themselves. For example, the subgroup of piston machine mechanisms contains items with various arrangements of the piston units; the subgroup of mechanisms for operating claw motions of motion picture cameras contains mechanisms that have the same kinematic structure but differ in design; etc.

4. How to Use the Handbook

All the mechanisms are shown on separate charts to make it easier to find the one required. Each chart contains the name of the mechanism, its drawing and description. The serial number of the mechanism is given in the upper left-hand corner; the two indices, in the upper right-hand corner. The upper letter index refers to the group of the basic classification; the lower index, to the subgroup of the basic classification to which the mechanism belongs. Such a number and index system enables references to be made to any mechanism in various ways depending upon the requirements.

Table 2 (page 32 through 41) lists the mechanisms on the basis of their service function. Alongside the names of the subgroups, arranged in alphabetical order of the indices, are the indices of the subgroups and groups of the basic classification, as well as the serial numbers that run throughout the handbook (the numbers at the upper left-hand corners of the charts). Thus if the designer wishes to find all possible schemes of brake mechanisms, he can see in Table 2 that they are described in the following groups and have the following serial numbers:

SL	252	through	257	FL	1975	through	1985
LW	858	"	876	WL	2194		
LG	1319	"	1321	LS	2267		

The full name of each separate brake mechanism can be found in the index at the back of each volume of the handbook.

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Table I

CLASSIFICATION OF MECHANISMS BASED ON STRUCTURAL FEATURES

Group No.	I			
Group name	Elements of Mechanisms			
Group index	EM			
	No.	Name	Subgroup index	Mechanism No.
	1.	Kinematic pairs	KP	1 through 54
	2.	Movable joints	MJ	55 through 119
Group No.	II			
Group name	Simple Lever Mechanisms			
Group index	SL			
	No.	Name	Subgroup index	Mechanism No.
	1.	Lever mechanisms	L	120 through 162
	2.	Gripping, clamping and expanding mechanisms	GC	163 through 245
	3.	Balance mechanisms	B	246 through 251
	4.	Brake mechanisms	Br	252 through 257
	5.	Stop, detent and locking mechanisms	SD	258 through 334

Table I (continued)

Group No.	II			
Group name	Simple Lever Mechanisms			
Group index	SL			
	No.	Name	Subgroup index	Mechanism No.
	6.	Switching, engaging and disengaging mechanisms	SE	335 through 361
	7.	Indexing mechanisms	I	362 through 405
	8.	Sorting and feeding mechanisms	SF	406 through 429
	9.	Governor mechanisms	G	430 through 440
	10.	Clutch and coupling mechanisms	C	441 through 459
	11.	Mechanisms of measuring and testing devices	M	460 through 478
	12.	Hammer, press and die mechanisms	HP	479 through 483
	13.	Key mechanisms	K	484 through 487
	14.	Mechanisms of materials handling equipment	MH	488 through 492
	15.	Safety mechanisms	S	493 and 494
	16.	Link-length adjustment mechanisms	LL	495 through 502
	17.	Mechanisms for mathematical operations	MO	503 through 506
	18.	Contacting lever mechanisms	CL	507 through 523
	19.	Mechanisms of other functional devices	FD	524 through 538

Table 1 (continued)

Group No.	III			
Group name	Linkwork			
Group index	LW			
	No.	Name	Subgroup index	Mechanism No.
	1.	General-purpose four-link mechanisms	4L	539 through 581
	2.	General-purpose five-link mechanisms	5L	582 through 589
	3.	General-purpose six-link mechanisms	6L	590 through 608
	4.	General-purpose multiple-link mechanisms	ML	609 through 622
	5.	Parallel-crank mechanisms	PC	623 through 640
	6.	Crossed-crank mechanisms	CC	641, 642 and 643
	7.	Guiding mechanisms and inversors	GI	644 through 740
	8.	Mechanisms for mathematical operations	MO	741 through 745
	9.	Dwell mechanisms	D	746 through 762
	10.	Mechanisms for generating curves	Ge	763 through 771
	11.	Operating claw mechanisms of motion picture cameras	OC	772 through 780
	12.	Balance mechanisms	B	781 through 795
	13.	Clutch and coupling mechanisms	C	796 through 801
	14.	Sorting and feeding mechanisms	SF	802 through 808
	15.	Safety mechanisms	S	809, 810 and 811
	16.	Governor mechanisms	G	812 through 815
	17.	Mechanisms of measuring and testing devices	M	816 through 824

Table I (continued)

Group No.	III			
Group name	Linkwork			
Group index	LW			
	No.	Name	Subgroup index	Mechanism No.
	18.	Indexing mechanisms	I	825
	19.	Mechanisms of materials handling equipment	MH	826 through 830
	20.	Pantograph mechanisms	P	831 through 857
	21.	Brake mechanisms	Br	858 through 876
	22.	Hammer, press and die mechanisms	HP	877 and 878
	23.	Mechanisms of other functional devices	FD	879 through 912
Group No.	IV			
Group name	Link-Gear Mechanisms			
Group index	LG			
	No.	Name	Subgroup index	Mechanism No.
	1.	General-purpose three-link mechanisms	3L	913 through 927
	2.	General-purpose four-link mechanisms	4L	928 through 993
	3.	General-purpose five-link mechanisms	5L	994 through 999
	4.	General-purpose six-link mechanisms	6L	1000 through 1027

Table 1 (continued)

Group No.	IV			
Group name	Link-Gear Mechanisms			
Group index	LG			
	No.	Name	Subgroup index	Mechanism No.
	5.	General-purpose multiple-link mechanisms	ML	1028 through 1042
	6.	Mechanisms for generating curves	Ge	1043 through 1255
	7.	Mechanisms for mathematical operations	MO	1256 through 1318
	8.	Brake mechanisms	Br	1319, 1320 and 1321
	9.	Wobble plate mechanisms	WP	1322 and 1323
	10.	Hammer, press and die mechanisms	HP	1324 and 1325
	11.	Governor mechanisms	G	1326 through 1329
	12.	Valve gear mechanisms	VG	1330 through 1336
	13.	Dwell mechanisms	D	1337 through 1354
	14.	Guiding mechanisms and inversors	GI	1355 through 1376
	15.	Switching, engaging and disengaging mechanisms	SE	1377
	16.	Sorting and feeding mechanisms	SF	1378 through 1381
	17.	Operating claw mechanisms of motion picture cameras	OC	1382 through 1395
	18.	Clutch and coupling mechanisms	C	1396 and 1397
	19.	Key mechanisms	K	1398
	20.	Piston machine mechanisms	PM	1399 through 1413

Table 1 (continued)

Group No.	IV			
Group name	Link-Gear Mechanisms			
Group index	LG			
	No.	Name	Subgroup index	Mechanism No.
	21.	Aircraft landing gear mechanisms	AL	1414 through 1443
	22.	Mechanisms of measuring and testing devices	M	1444 and 1445
	23.	Pantograph mechanisms	P	1446 and 1447
	24.	Mechanisms of other functional devices	FD	1448 through 1474
Group No.	V			
Group name	Slider-Crank Mechanisms			
Group index	SC			
	No.	Name	Subgroup index	Mechanism No.
	1.	General-purpose three-link mechanisms	3L	1475 and 1476
	2.	General-purpose four-link mechanisms	4L	1477 through 1503
	3.	General-purpose six-link mechanisms	6L	1504 through 1528
	4.	General-purpose multiple-link mechanisms	ML	1529 through 1534

Table 1 (continued)

Group No.	V			
Group name	Slider-Crank Mechanisms			
Group index	SC			
	No.	Name	Subgroup index	Mechanism No.
	5.	Guiding mechanisms and inversors	GI	1535 through 1559
	6.	Piston machine mechanisms	PM	1560 through 1591
	7.	Wobble plate mechanisms	WP	1592 through 1600
	8.	Mechanisms for mathematical operations	MO	1601 and 1602
	9.	Mechanisms for generating curves	Ge	1603 through 1624
	10.	Stop, detent and locking mechanisms	SD	1625 through 1628
	11.	Hammer, press and die mechanisms	HP	1629 through 1633
	12.	Governor mechanisms	G	1634 through 1639
	13.	Gripping, clamping and expanding mechanisms	GC	1640 through 1644
	14.	Dwell mechanisms	D	1645 through 1648
	15.	Mechanisms of materials handling equipment	MH	1649
	16.	Operating claw mechanisms of motion picture cameras	OC	1650 through 1657
	17.	Valve gear mechanisms	VG	1658 and 1659
	18.	Aircraft landing gear mechanisms	AL	1660 through 1664

Table 1 (continued)

Group No.	V			
Group name	Slider-Crank Mechanisms			
Group index	SC			
	No.	Name	Subgroup index	Mechanism No.
	19.	Sorting and feeding mechanisms	SF	1665 through 1669
	20.	Mechanisms of measuring and testing devices	M	1670 and 1671
	21.	Mechanisms of other functional devices	FD	1672 through 1683
Group No.	VI			
Group name	Lever-Cam Mechanisms			
Group index	LC			
	No.	Name	Subgroup index	Mechanism No.
	1.	General-purpose four-link mechanisms	4L	1684 through 1687
	2.	General-purpose five-link mechanisms	5L	1688 through 1697
	3.	General-purpose multiple-link mechanisms	ML	1698
	4.	Clutch and coupling mechanisms	C	1699 and 1700
	5.	Dwell mechanisms	D	1701, 1702 and 1703
	6.	Gripping, clamping and expanding mechanisms	GC	1704, 1705 and 1706
	7.	Governor mechanisms	G	1707, 1708 and 1709
	8.	Rolling lever mechanisms	RL	1710 through 1724

Table I (continued)

Group No.	VI			
Group name	Lever-Cam Mechanisms			
Group index	LC			
	No.	Name	Subgroup index	Mechanism No.
	9.	Stop, detent and locking mechanisms	SD	1725
	10.	Mechanisms of measuring and testing devices	M	1726, 1727 and 1728
	11.	Mechanisms of other functional devices	FD	1729 through 1732
Group No.	VII			
Group name	Gear-Lever Mechanisms			
Group index	GL			
	No.	Name	Subgroup index	Mechanism No.
	1.	General-purpose three-link mechanisms	3L	1733
	2.	General-purpose four-link mechanisms	4L	1734 through 1738
	3.	General-purpose five-link mechanisms	5L	1739 through 1744
	4.	General-purpose six-link mechanisms	6L	1745
	5.	General-purpose multiple-link mechanisms	ML	1746 through 1749
	6.	Dwell mechanisms	D	1750 through 1760
	7.	Governor mechanisms	G	1761

Table I (continued)

Group No.	VII			
Group name	Gear-Lever Mechanisms			
Group index	GL			
	No.	Name	Subgroup index	Mechanism No.
	8.	Mechanisms for mathematical operations	MO	1762 and 1763
	9.	Operating claw mechanisms of motion picture cameras	OC	1764
	10.	Piston machine mechanisms	PM	1765
	11.	Hammer, press and die mechanisms	HP	1766, 1767 and 1768
	12.	Mechanisms for generating curves	Ge	1769 through 1773
	13.	Switching, engaging and disengaging mechanisms	SE	1774
	14.	Mechanisms of measuring and testing devices	M	1775 through 1782
	15.	Mechanisms of other functional devices	FD	1783 through 1788
Group No.	VIII			
Group name	Lever-Ratchet Mechanisms			
Group index	LR			
	No.	Name	Subgroup index	Mechanism No.
	1.	General-purpose four-link mechanisms	4L	1789 through 1802
	2.	General-purpose five-link mechanisms	5L	1803 through 1806

Table 1 (continued)

Group No.	VIII			
Group name	Lever-Ratchet Mechanisms			
Group index	LR			
	No.	Name	Subgroup index	Mechanism No.
	3.	General-purpose six-link mechanisms	6L	1807 through 1818
	4.	General-purpose multiple-link mechanisms	ML	1819 through 1834
	5.	Dwell mechanisms	D	1835
	6.	Switching, engaging and disengaging mechanisms	SE	1836, 1837 and 1838
	7.	Stop, detent and locking mechanisms	SD	1839, 1840 and 1841
	8.	Mechanisms of materials handling equipment	MH	1842
	9.	Sorting and feeding mechanisms	SF	1843 and 1844
	10.	Mechanisms of measuring and testing devices	M	1845
	11.	Mechanisms of other functional devices	FD	1846 through 1856
Group No.	IX			
Group name	Flexible-Link Lever Mechanisms			
Group index	FL			
	No.	Name	Subgroup index	Mechanism No.
	1.	General-purpose four-link mechanisms	4L	1857 through 1860
	2.	General-purpose five-link mechanisms	5L	1861 through 1865

Table I (continued)

Group No.	IX			
Group name	Flexible-Link Lever Mechanisms			
Group index	FL			
	No.	Name	Subgroup index	Mechanism No.
	3.	General-purpose six-link mechanisms	6L	1866 through 1890
	4.	General-purpose multiple-link mechanisms	ML	1891 through 1920
	5.	Dwell mechanisms	D	1921 through 1938
	6.	Crawler mechanisms	Cr	1939 through 1970
	7.	Mechanisms of measuring and testing devices	M	1971 and 1972
	8.	Sorting and feeding mechanisms	SF	1973 and 1974
	9.	Brake mechanisms	Br	1975 through 1985
	10.	Tilting crawler mechanisms	TC	1986 through 2016
	11.	Balance mechanisms	B	2017 and 2018
	12.	Mechanisms of materials handling equipment	MH	2019 through 2024
	13.	Mechanisms for generating curves	Ge	2025, 2026 and 2027
	14.	Satellite mechanisms	Sa	2028 through 2104
	15.	Mechanisms of other functional devices	FD	2105 through 2108
Group No.	X			
Group name	Elastic-Link Lever Mechanisms			
Group index	EL			
	No.	Name	Subgroup index	Mechanism No.
	1.	General-purpose four-link mechanisms	4L	2109 through 2113
	2.	General-purpose five-link mechanisms	5L	2114 through 2117

Table 1 (continued)

Group No.	X			
Group name	Elastic-Link Lever Mechanisms			
Group index	EL			
	No.	Name	Subgroup index	Mechanism No.
	3.	General-purpose six-link mechanisms	6L	2118, 2119 and 2120
	4.	Hammer, press, and die mechanisms	HP	2121 through 2124
	5.	Operating claw mechanisms of motion picture cameras	OC	2125, 2126 and 2127
	6.	Clutch and coupling mechanisms	C	2128 and 2129
	7.	Switching, engaging and disengaging mechanisms	SE	2130 through 2136
	8.	Mechanisms of measuring and testing devices	M	2137 through 2140
	9.	Mechanisms for mathematical operations	MO	2141
	10.	Governor mechanisms	G	2142
	11.	Mechanisms of vibrating machines and devices	VM	2143 through 2158

Group No.	XI			
Group name	Wedge-Lever Mechanisms			
Group index	WL			
	No.	Name	Subgroup index	Mechanism No.
	1.	General-purpose three-link mechanisms	3L	2159 through 2174
	2.	General-purpose four-link mechanisms	4L	2175, 2176 and 2177

Table 1 (continued)

Group No.	XI			
Group name	Wedge-Lever Mechanisms			
Group index	WL			
	No.	Name	Subgroup index	Mechanism No.
	3.	General-purpose six-link mechanisms	6L	2178
	4.	Dwell mechanisms	D	2179
	5.	Stop, detent and locking mechanisms	SD	2180 through 2187
	6.	Sorting and feeding mechanisms	SF	2188
	7.	Clutch and coupling mechanisms	C	2189
	8.	Mechanisms of measuring and testing devices	M	2190, 2191 and 2192
	9.	Hammer, press and die mechanisms	HP	2193
	10.	Brake mechanisms	Br	2194
	11.	Gripping, clamping and expanding mechanisms	GC	2195 through 2199
	12.	Mechanisms of other functional devices	FD	2200
Group No.	XII			
Group name	Lever-Screw Mechanisms			
Group index	LS			
	No.	Name	Subgroup index	Mechanism No.
	1.	General-purpose three-link mechanisms	3L	2201 through 2225
	2.	General-purpose four-link mechanisms	4L	2226, 2227 and 2228

Table I (continued)

Group No.	XII			
Group name	Lever-Screw Mechanisms			
Group index	LS			
	No.	Name	Subgroup index	Mechanism No.
	3.	General-purpose five-link mechanisms	5L	2229 through 2237
	4.	General-purpose multiple-link mechanisms	ML	2238, 2239 and 2240
	5.	Sorting and feeding mechanisms	SF	2241
	6.	Hammer, press and die mechanisms	HP	2242, 2243 and 2244
	7.	Switching, engaging and disengaging mechanisms	SE	2245 and 2246
	8.	Governor mechanisms	G	2247 and 2248
	9.	Mechanisms of materials handling equipment	MH	2249
	10.	Precise setting mechanisms	PS	2250 through 2254
	11.	Mechanisms for mathematical operations	MO	2255 through 2266
	12.	Brake mechanisms	Br	2267
	13.	Mechanisms of measuring and testing devices	M	2268 through 2271
	14.	Mechanisms of other functional devices	FD	2272 through 2288

No.	Sub-group index	Subgroup name	Group			
			EM	SL	LW	LG
1	AL	Aircraft landing gear mechanisms				1414 through 1443
2	B	Balance mechanisms		246 through 251	781 through 795	
3	Br	Brake mechanisms		252 through 257	858 through 876	1319 through 1321
4	C	Clutch and coupling mechanisms		441 through 459	796 through 801	1396 and 1397
5	CC	Crossed-crank mechanisms			641 through 643	
6	CL	Contacting lever mechanisms		507 through 523		
7	Cr	Crawler mechanisms				
8	D	Dwell mechanisms			746 through 762	1337 through 1354
9	FD	Mechanisms of other functional devices		524 through 538	879 through 912	1442 through 1474
10	G	Governor mechanisms		430 through 440	812 through 815	1326 through 1329

Table 2

BASED ON FUNCTIONAL FEATURES

index							
SC	LC	GL	LR	FL	EL	WL	LS
1660 through 1664							
				2017 and 2018			
				1975 through 1985		2194	2267
	1699 and 1700				2128 and 2129	2189	
				1939 through 1970			
1645 through 1648	1701 through 1703	1750 through 1760	1835	1921 through 1938		2179	
1672 through 1683	1729 through 1732	1783 through 1788	1846 through 1856	2105 through 2108	2114 through 2117	2200	2282 through 2288
1634 through 1639	1808 and 1809	1761			2142		2247 and 2248

No.	Sub-group Index	Subgroup name	Group			
			EM	SL	LW	LG
11	GC	Gripping, clamping and expanding mechanisms		163 through 245		
12	Ge	Mechanisms for generating curves			763 through 771	1043 throug 1255
13	GI	Guiding mechanisms and inversors			644 through 740	1355 through 1376
14	HP	Hammer, press and die mechanisms		479 through 483	877 and 878	1324 and 1325
15	I	Indexing mechanisms		362 through 405	825	
16	K	Key mechanisms		484 through 487		1398
17	KP	Kinematic pairs	1 through 54			
18	L	Lever mechanisms		120 through 162		
19	3L	General-purpose three-link mechanisms				913 through 927
20	4L	General-purpose four-link mechanisms			539 through 581	928 through 993

Table 2 (continued)

Index							
SC	LC	GL	LR	FL	EL	WL	LS
1640 through 1644	1704 through 1706					2195 through 2199	
1603 through 1624		1769 through 1733		2025 through 2027			
1535 through 1559							
1629 through 1633		1766 through 1768			2121 through 2124	2193	2242 through 2244
1475 and 1476		1733				2159 through 2174	2201 through 2225
1477 through 1503	1684 through 1687	1734 through 1738	1789 through 1802	1857 through 1860	2109 through 2113	2175 through 2177	2226 through 2228

No.	Sub-group index	Subgroup name	Group			
			EM	SL	LW	LG
21	5L	General-purpose five-link mechanisms			582 through 589	994 through 999
22	6L	General-purpose six-link mechanisms			590 through 608	1000 through 1027
23	LL	Link-length adjustment mechanisms		495 through 502		
24	M	Mechanisms of measuring and testing devices		460 through 478	816 through 824	1444 and 1445
25	MH	Mechanisms of materials handling equipment		488 through 492	826 through 830	
26	MJ	Movable joints	55 through 119			
27	ML	General-purpose multiple-link mechanisms			609 through 622	1042
28	MO	Mechanisms for mathematical operations		503 through 506	741 through 745	1256 through 1318
29	OC	Operating claw mechanisms of motion picture cameras			772 through 780	1382 through 1395
30	P	Pantograph mechanisms			831 through 857	1446 and 1447

Table 2 (continued)

Index							
SC	LC	GL	LR	FL	EL	WL	LS
1475 and 1476	1688 through 1697	1739 through 1744	1803 through 1806	1861 through 1865		2159 through 2174	2229 through 2237
1504 through 1528			1807 through 1818	1866 through 1890	2118 through 2120		
1670 and 1671	1726 through 1728	1775 through 1782	1845	1971 and 1972	2137 through 2140	2190 through 2192	2268 through 2271
1649			1842	2019 through 2024			2249
1529 through 1534	1698	1746 through 1749	1819 through 1834	1891 through 1920			2238 through 2240
1601 and 1602		1762 and 1763			2141		2255 through 2266
1650 through 1657	1745	1864			2125 through 2127	2178	

No.	Sub-group index	Subgroup name	Group			
			EM	SL	LW	LG
31	PC	Parallel-crank mechanisms			623 through 640	
32	PM	Piston machine mechanisms				1399 through 1413
33	PS	Precise setting mechanisms				
34	RL	Rolling lever mechanisms				
35	S	Safety mechanisms		493 and 494	809 through 811	
36	Sa	Satellite mechanisms				
37	SD	Stop, detent and locking mechanisms		258 through 334		
38	SE	Switching, engaging and disengaging mechanisms		335 through 361		1337
39	SF	Sorting and feeding mechanisms		406 through 429	802 through 808	1378 through 1381
40	TC	Tilting crawler mechanisms				

Table 2 (continued)

Index							
SC	LC	GL	LR	FL	EL	WL	LS
1560 through 1591		1765					
							2250 through 2254
	1710 through 1724						
				2028 through 2104			
1625 through 1628	1725		1839 through 1841			2180 through 2187	
		1774	1836 through 1838		2130 through 2136		2245 and 2246
1665 through 1669			1843 and 1844	1973 and 1974		2188	2241
				1986 through 2016			

No.	Sub-group Index	Subgroup name	Group			
			EM	SL	LW	LG
41	VG	Valve gear mechanisms				1330 through 1336
42	VM	Mechanisms of vibrating machines and devices				
43	WP	Wobble plate mechanisms				1322 and 1323

Table 2 (continued)

Index								
	SC	LC	GL	LR	FL	EL	WL	LS
	1658 and 1659							
						2143 through 2158		
	1592 through 1600							

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SECTION ONE

Elements of Mechanisms

EM

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1. Kinematic Pairs KP (1 through 54)
2. Movable Joints MJ (55 through 119)

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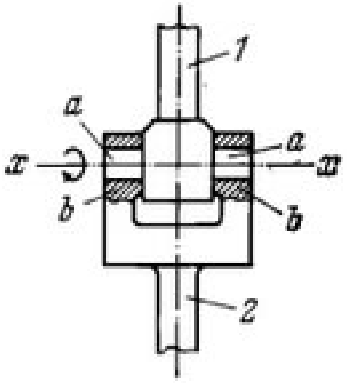
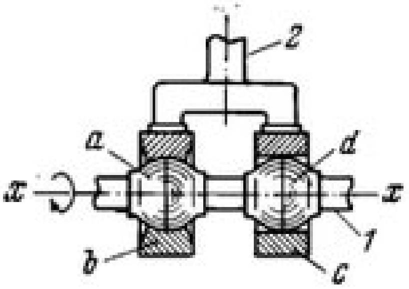
1. KINEMATIC PAIRS (1 through 54)

1	**SINGLE-MOTION TURNING KINEMATIC PAIR WITH CYLINDRICAL TRUNNIONS**	EM KP



Link *1* has two round cylindrical trunnions *a* fitting into cylindrical holes *b* of link *2*. With respect to each other, links *1* and *2* accomplish a single turning motion about common axis *x-x*.

2	**SINGLE-MOTION TURNING KINEMATIC PAIR WITH SPHERICAL JOURNALS**	EM KP



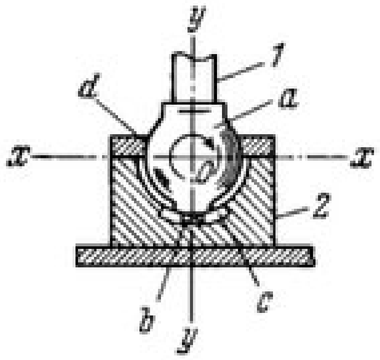
Link *1* has two spherical journals *a* and *d*. Journal *a* fits into spherical surface *b* of link *2*, and journal *d* contacts cylindrical surface *c* of link *2*. With respect to each other, links *1* and *2* accomplish a single turning motion about common axis *x-x*.

3

SINGLE-MOTION TURNING KINEMATIC PAIR WITH A SPHERICAL PIVOT AND A LUG

EM

KP



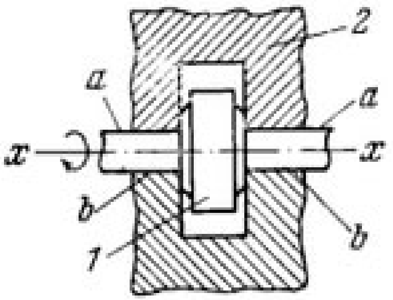
Link *1* has a spherical pivot *a* which contacts spherical surface *d* of link *2*. Pivot *a* has a rectangular lug *b* with parallel annular side surfaces that fit in and slide along cylindrical groove *c* of link *2*. With respect to each other, links *1* and *2* accomplish a single turning motion about a common axis perpendicular to plane *xOy* and passing through point *O*.

4

SINGLE-MOTION TURNING KINEMATIC PAIR WITH A CYLINDRICAL SHAFT

EM

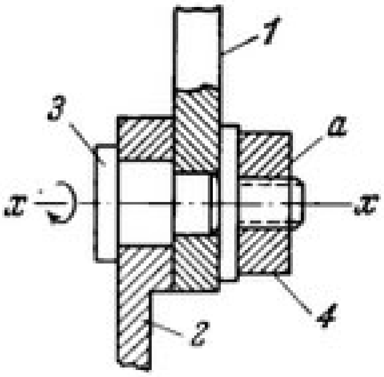
KP



Link *1* is fixed on shaft (or pin) *a* which fits into holes *b* in link *2*. With respect to each other, links *1* and *2* accomplish a single turning motion about common axis *x-x*.

5 SINGLE-MOTION TURNING KINEMATIC PAIR WITH AN INTERMEDIATE SHAFT

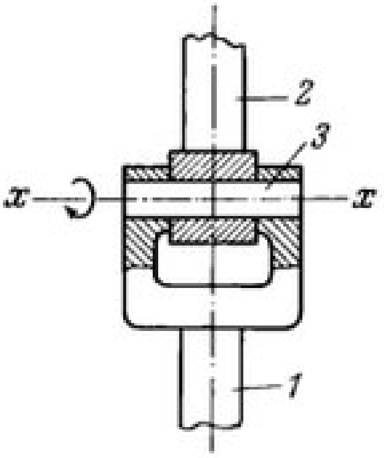
EM
KP



Links *1* and *2* rotate freely on two-step shaft *3* which has a threaded end *a*. Nut *4* holds links *1* and *2* on stepped shaft *3*. With respect to each other, links *1* and '*2* accomplish a single turning motion about common axis *x-x*.

6 SINGLE-MOTION TURNING KINEMATIC PAIR WITH A FIXED INTERMEDIATE SHAFT

EM
KP

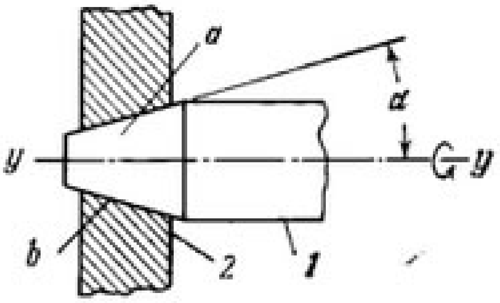


Link *2* turns freely on intermediate shaft *3* which is fixed in link *1*. With respect to each other, links *1* and *2* accomplish a single turning motion about common axis *x-x*.

7

SINGLE-MOTION TURNING KINEMATIC PAIR WITH A TAPERED JOURNAL

EM
KP



Link *1* ends in tapered journal *a* with the angle of taper α. Journal *a* fits into tapered hole *b* in link *2* which has the same angle of taper. With respect to each other, links *1* and *2* accomplish a single turning motion about common axis *y-y*.

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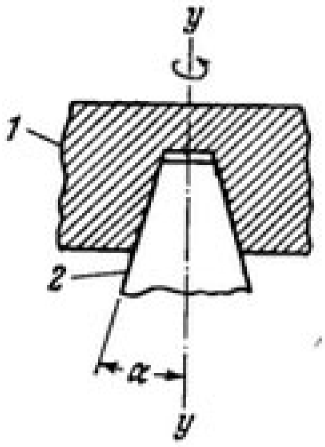
8

SINGLE-MOTION TURNING KINEMATIC PAIR WITH A CONICAL PIVOT

EM
KP



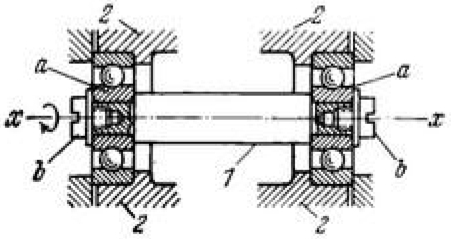
Link *1* has an internal conical surface with the angle of taper α. This surface fits on link *2* which has the same angle of taper. With respect to each other, links *1* and *2* accomplish a single turning motion about common axis *y-y*.

9

SINGLE-MOTION TURNING KINEMATIC PAIR WITH TWO BALL BEARINGS

EM

KP



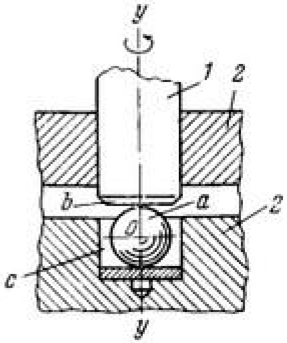
Link *1*, rotating about axis *x-x*, is mounted in ball bearings *a*. Screws *b* locate link *1* with respect to ball bearings *a*. With respect to each other, links *1* and *2* accomplish a single turning motion about common axis *x-x*.

10

SINGLE-MOTION TURNING KINEMATIC PAIR WITH A BALL STEP BEARING

EM

KP



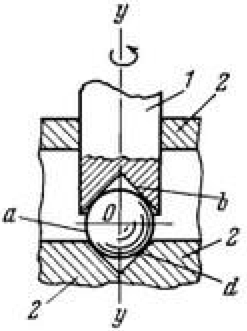
Link *1*, rotating about axis *y-y*, has a flat end face *b* which rests on ball *a*. The ball has some freedom of movement in socket *c* in link *2*. With respect to each other, links *1* and *2* accomplish a single turning motion about common axis *y-y*.

11

SINGLE-MOTION TURNING KINEMATIC PAIR WITH A BALL STEP BEARING

EM

KP



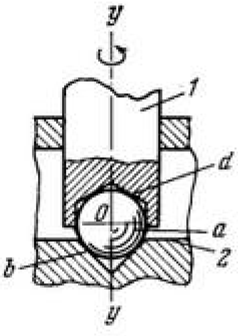
Link *1*, rotating about axis *y-y*, has a conical recess *b* in its end face. This recess fits over ball *a* which rests in conical recess *d* of link *2*. With respect to each other, links *1* and *2* accomplish a single turning motion about common axis *y-y*.

12

SINGLE-MOTION TURNING KINEMATIC PAIR WITH A BALL STEP BEARING

EM

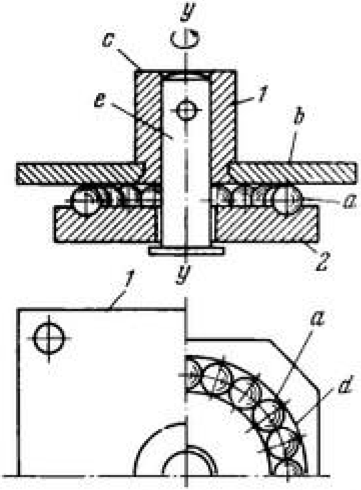
KP



Link *1*, rotating about axis *y-y*, has a recess with facets *d* in its end face. This recess fits over ball *a* which rests in conical recess *b* of link *2*. With respect to each other, links *1* and *2* accomplish a single turning motion about the common axis *y-y*.

13 SINGLE-MOTION TURNING KINEMATIC PAIR WITH A BALL THRUST BEARING

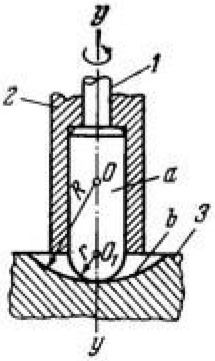
EM
KP



Link *1*, rotating about axis *y-y*, consists of sleeve *c*, pin *e* and disk *b*, rigidly fastened together. Disk *b* of link *1* rests on balls *a* which can roll along circular groove *d*. With respect to each other, links *1* and *2* accomplish a single turning motion about axis *y-y*.

14 SINGLE-MOTION TURNING KINEMATIC PAIR WITH A SPHERICAL BEARING SURFACE

EM
KP



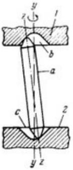
Link *1*, rotating about axis *y-y*, has pin *a* with a spherical end of radius r. Pin *a* rests in spherical recess *b* of radius R in link *3*. Links *2* and *3* are fastened rigidly together. With respect to each other, links *1* and *2* accomplish a single turning motion about the common axis *y-y*.

15

SINGLE-MOTION TURNING KINEMATIC PAIR WITH A SELF-ALIGNING SUPPORT BEARING

EM

KP



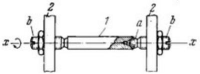
Link *1*, rotating about axis *y-y*, has recess *b* into which one end of component *a* enters. The other end of component *a* enters recess *c* in link *2*. Upon rotation of link *1* about axis *y-y*, component *a* aligns itself to the position where axis *z-z* coincides with axis *y-y*. Then, with respect to each other, links *1* and *2* accomplish a single turning motion about common axis *y-y*.

16

SINGLE-MOTION TURNING KINEMATIC PAIR WITH ADJUSTING SCREWS

EM

KP



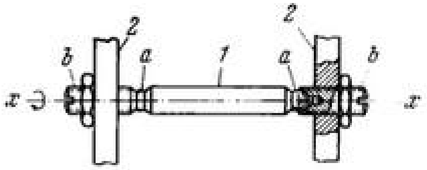
Link *1* has conical recesses at its ends which receive ball tips *a* of screws *b* in link *2*. Screws *b* adjust the axial position of link *1*. With respect to each other, links *1* and *2* accomplish a single turning motion about common axis *x-x*.

17

SINGLE-MOTION TURNING KINEMATIC PAIR WITH ADJUSTING SCREWS

EM

KP



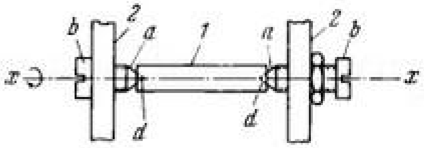
Link *1* ends in ball tips *a* which enter corresponding conical recesses at the ends of screws *b* of link *2*. Screws *b* adjust the axial position of link *1*. With respect to each other, links *1* and *2* accomplish a single turning motion about common axis *x*-*x*.

18

SINGLE-MOTION TURNING KINEMATIC PAIR WITH ADJUSTING SCREWS

EM

KP



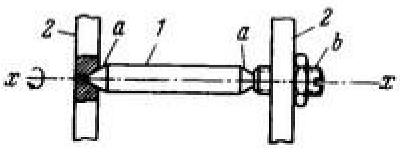
Link *1* has conical recesses *d* at its ends which receive conical tips *a* of screws *b* in link *2*. Screws *b* adjust the axial position of link *1*. With respect to each other, links *1* and *2* accomplish a single turning motion about common axis *x*-*x*.

19

SINGLE-MOTION TURNING KINEMATIC PAIR WITH AN ADJUSTING SCREW

EM

KP

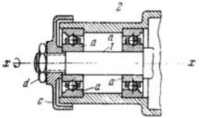


Conical tips *a* at the ends of link *1* enter the conical recesses of link *2* and of the end of screw *b*. This screw adjusts the axial position of link *1*. With respect to each other, links *1* and *2* accomplish a single turning motion about common axis *x*-*x*.

20

SINGLE-MOTION TURNING KINEMATIC PAIR WITH A CLAMPING NUT

EM
KP

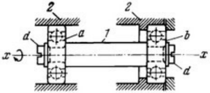


Link *1*, rotating about axis *x-x*, is mounted in ball bearings *a*. By means of nut *d* and cap *c*, link *1* is located axially with respect to link *2*. With respect to each other, links *1* and *2* accomplish a single turning motion about common axis *x-x*.

21

SINGLE-MOTION TURNING KINEMATIC PAIR WITH A SELF-LOCATING BEARING

EM
KP

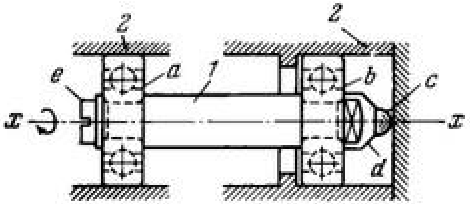


Link *1* runs in bearings *a* and *b* about axis *x-x*. Axially, bearing *b* is rigidly fixed in link *2*. Bearing *a* has a certain freedom of location along axis *x-x*. Link *1* is located axially with respect to link *2* by screws *d*. With respect to each other, links *1* and *2* accomplish a single turning motion about common axis *x-x*.

22

SINGLE-MOTION TURNING KINEMATIC PAIR WITH A SELF-LOCATING BEARING

EM
KP

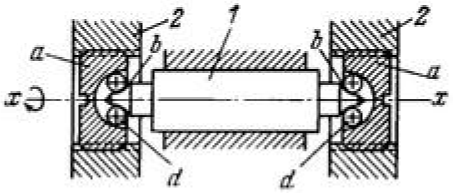


Link *1* runs in bearings *a* and *b* about axis *x-x*. Ball *c*, mounted in holder *d*, bears against link *2*. Bearing *a* has a certain freedom of location along axis *x-x*. Link *1* is located axially with respect to link *2* by screw *e*. With respect to each other, links *1* and *2* accomplish a single turning motion about common axis *x-x*.

23

SINGLE-MOTION TURNING KINEMATIC PAIR WITH ADJUSTABLE BEARINGS

EM
KP

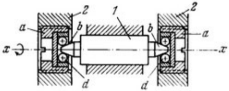


Link *1*, rotating about axis *x-x*, has arc-shaped surfaces of revolution *b* at its ends. These surfaces rest in balls *d*. Link *1* is located axially with respect to link *2* by screw devices *a*. With respect to each other, links *1* and *2* accomplish a single turning motion about common axis *x-x*.

24 SINGLE-MOTION TURNING KINEMATIC PAIR WITH ADJUSTABLE BEARINGS

EM

KP



Link *1*, rotating about axis *x-x*, has conical tips *b* at its ends. These tips rest in balls *d*. Link *1* is located axially with respect to link *2* by screw devices *a*. With respect to each other, links *1* and *2* accomplish a single turning motion about the common axis *x-x*.

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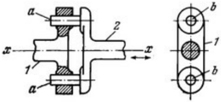
25 SINGLE-MOTION SLIDING KINEMATIC PAIR WITH CYLINDRICAL PINS

EM

KP



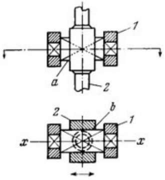
Link *2* has two cylindrical pins *a* fitting into cylindrical holes *b* of link *1*. With respect to each other, links *1* and *2* accomplish a single translational motion along common axis *x-x*.

26

SINGLE-MOTION SLIDING KINEMATIC PAIR WITH A RECTANGULAR SLIDING MEMBER

EM

KP



Link *1* has sliding member *a* of rectangular cross section that fits rectangular hole *b* of link *2*. With respect to each other, links *1* and *2* accomplish a single translational motion along common axis *x*-*x*.

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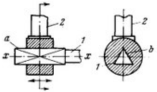
27

SINGLE-MOTION SLIDING KINEMATIC PAIR WITH A TRIANGULAR SLIDING MEMBER

EM

KP



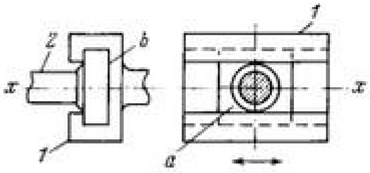
Link *1* has sliding member *a* of triangular cross section that fits triangular hole *b* of link *2*. With respect to each other, links *1* and *2* accomplish a single translational motion along the common axis *x*-*x*.

28

SINGLE-MOTION SLIDING KINEMATIC PAIR WITH A T-SLOT GUIDE

EM

KP



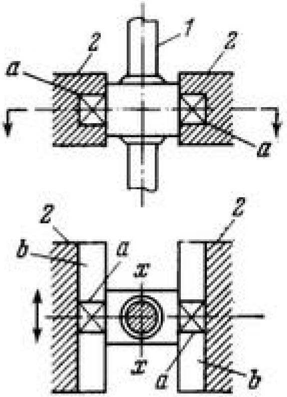
Link *1* has T-slot guide *b* into which sliding member *a* of link *2* fits. With respect to each other, links *1* and *2* accomplish a single translational motion along common axis *x-x*.

29

SINGLE-MOTION SLIDING KINEMATIC PAIR WITH TWO GUIDE SLOTS

EM

KP



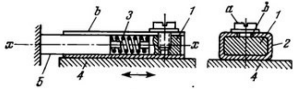
Link *1* has two sliding members *a* of rectangular cross section that fit into rectangular guide slots *b* of link *2*. With respect to each other, links *1* and *2* accomplish a single translational motion along common axis *x-x*.

30

SINGLE-MOTION SLIDING KINEMATIC PAIR WITH A MOVABLE BOX-SHAPED GUIDE

EM

KP



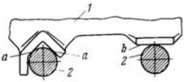
Sliding member 1 can slide along axis *x-x* in box-shaped guide 2. Screw *a*, fastened to sliding member 1, slides along slot *b* in guide 2. Sliding member 1 is spring-loaded by spring 3. Box-shaped guide 2 can slide on flat surface 4 along rectangular rod 5. With respect to each other, links 1 and 2 accomplish a single translational motion along the common axis *x-x*.

31

SINGLE-MOTION SLIDING KINEMATIC PAIR WITH ROUND CYLINDRICAL SLIDEWAYS

EM

KP

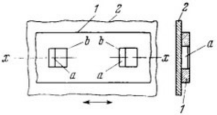


Link 1 has flat surfaces *a* and *b* which slide along round cylindrical slideways 2. With respect to each other, links 1 and 2 accomplish a single translational motion along an axis square to the plane of the drawing.

32

SINGLE-MOTION SLIDING KINEMATIC PAIR WITH GUIDING BLOCKS

EM
KP



Link *1* has slots *b* by means of which it slides along blocks *a* of link *2*. With respect to each other, links *1* and *2* accomplish a single translational motion along common axis *x-x*.

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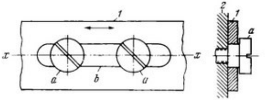
33

SINGLE-MOTION SLIDING KINEMATIC PAIR WITH GUIDING SCREWS

EM
KP



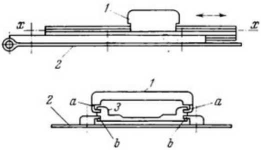
Link *1* has slot *b* by means of which it slides along screws *a* which are secured in link *2*. With respect to each other, links *1* and *2* accomplish a single translational motion along common axis *x-x*.

34

SINGLE-MOTION DOUBLE SLIDING KINEMATIC PAIR

EM

KP



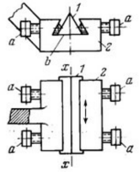
Link *1* has bent-over edges *a* which slide in guide slots of link *3*. Link *3*, in its turn, slides along guides *b* of link *2*. Link *1* can travel along axis *x-x* with respect to link *2* either together with or separately from link *3*.

35

SINGLE-MOTION SLIDING KINEMATIC PAIR WITH FOUR POSITIONING SCREWS

EM

KP



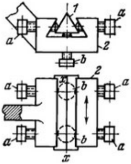
Sliding member *1* of triangular cross section slides along guide *b* of link *2*. Screws *a* serve to set the sliding member in the required position with respect to link *2*. With respect to each other, links *1* and *2* accomplish a single translational motion along common axis *x-x*.

36

SINGLE-MOTION SLIDING KINEMATIC PAIR WITH SIX POSITIONING SCREWS

EM

KP



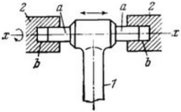
Sliding member *1* of triangular cross section slides along supporting screws *b*. Screws *a* serve to set the sliding member in the required position with respect to link *2*. With respect to each other, links *1* and *2* accomplish a single translational motion along common axis *x-x*.

37

TWO-MOTION CYLINDRICAL KINEMATIC PAIR WITH ROUND TRUNNIONS

EM

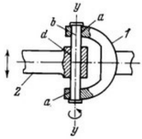
KP



Link *1* has two round cylindrical trunnions *a* fitting into cylindrical holes *b* of link *2*. With respect to each other, links *1* and *2* accomplish one translational motion along common axis *x-x* and one turning motion about the same axis *x-x*.

38 TWO-MOTION CYLINDRICAL KINEMATIC PAIR WITH AN INTERMEDIATE SHAFT

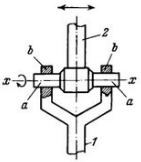
EM
KP



Link *1* has two cylindrical holes *a* in which round intermediate shaft *b* is mounted. This shaft slides along hole *d* in link *2*. With respect to each other, links *1* and *2* accomplish one translational motion along common axis *y-y* and one turning motion about the same axis *y-y*.

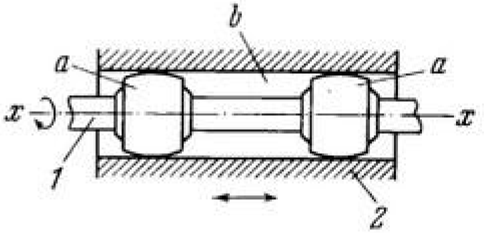
39 TWO-MOTION CYLINDRICAL KINEMATIC PAIR WITH TWO ROUND EYES

EM
KP



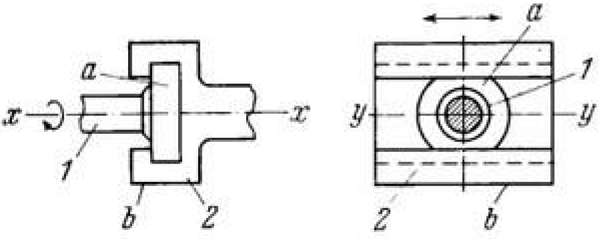
Link *2* has two cylindrical trunnions *a*, fitting into round cylindrical eyes *b* of link *1*. With respect to each other, links *1* and *2* accomplish one translational motion along common axis *x-x* and one turning motion about the same axis *x-x*.

40	TWO-MOTION CYLINDRICAL KINEMATIC PAIR WITH BARREL-SHAPED ELEMENTS	EM KP



Link *1* has two barrel-shaped elements *a* which slide along cylindrical channel *b* of link *2*. With respect to each other, links *1* and *2* accomplish one translational motion along common axis *x-x* and one turning motion about the same axis *x-x*.

41	TWO-MOTION PLANE KINEMATIC PAIR WITH A T-SLOT GUIDE	EM KP



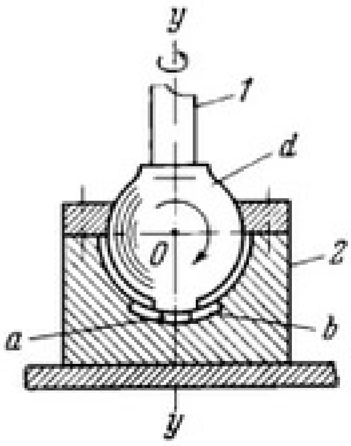
Link *1* has round cylindrical disk *a* sliding along T-slot guide *b* of link *2*. With respect to each other, links *1* and *2* accomplish one translational motion along axis *y-y* and one turning motion along axis *x-x*.

42

TWO-MOTION SPHERICAL KINEMATIC PAIR WITH A PIN AND GROOVE

EM

KP



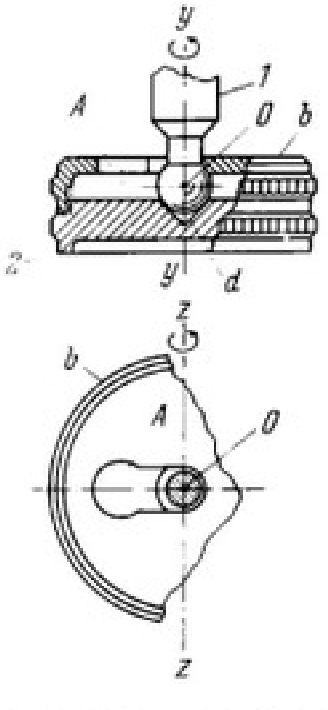
Link *1* has a ball end with spherical surface *d* and round cylindrical pin *a* sliding along circular groove *b*, of a width equal to the diameter of the pin. With respect to each other, links *1* and *2* accomplish two turning motions about axis *y-y* and about an axis passing through centre *O* of sphere *d* and perpendicular to the plane of circular groove *b*.

43

TWO-MOTION KINEMATIC PAIR WITH A BALL-SHAPED HEAD

EM

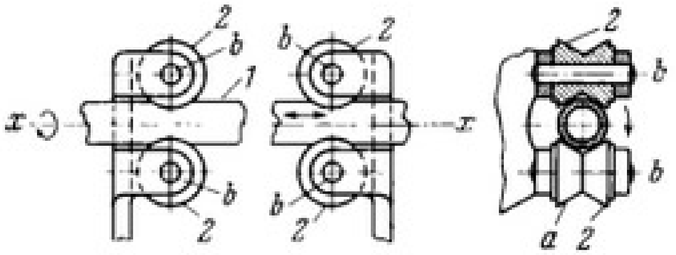
KP



Link *1* ends in a ball-shaped head with centre *O* which enters conical recess *d* of link *2*. Link *1* is held against link *2* by cover *b*. Hole *A* serves to insert the head inside cover *b*. With respect to each other, links *1* and *2* accomplish two turning motions about axes *z-z* and *y-y* which pass through point *O*, the centre of the spherical surface of link *1*.

44 TWO-MOTION CYLINDRICAL KINEMATIC PAIR WITH GUIDE ROLLERS

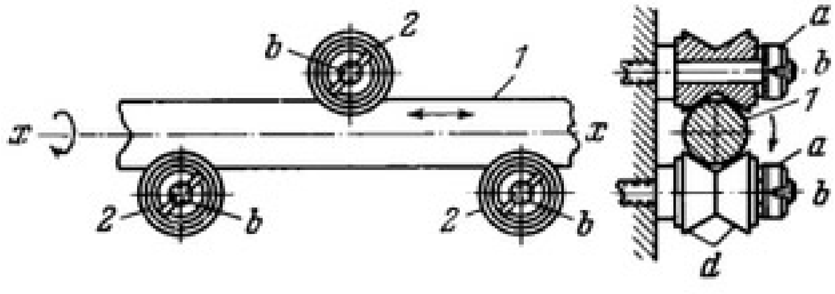
EM KP



Link *1*, of round cylindrical cross section, is arranged between guide rollers *2* which have annular vee grooves *a*. With respect to rollers *2*, link *1* accomplishes one translational motion along axis *x-x* and one turning motion about the same axis *x-x*. To reduce friction losses in the sliding of link *1* along axis *x-x*, rollers *2* rotate freely about their pins *b*.

45 TWO-MOTION CYLINDRICAL KINEMATIC PAIR WITH GUIDE ROLLERS

EM KP

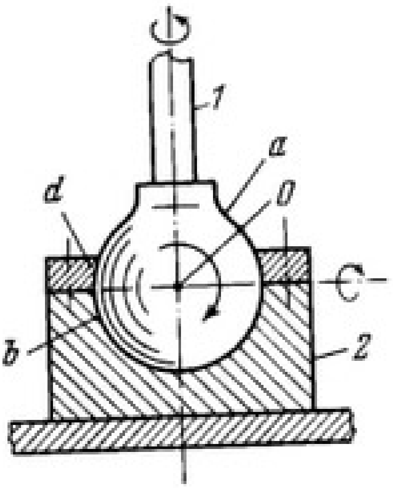


Link *1*, of round cylindrical cross section, is arranged between guide rollers *2* which have annular vee grooves *d*. Screws *a* adjust the axial position of the rollers. With respect to rollers *2*, link *1* accomplishes one translational motion along axis *x-x* and one turning motion about the same axis *x-x*. To reduce friction losses in the sliding of link *1* along axis *x-x*, rollers *2* rotate freely about their pins *b*.

46

THREE-MOTION SPHERICAL KINEMATIC PAIR WITH A BALL-SHAPED HEAD

EM
KP

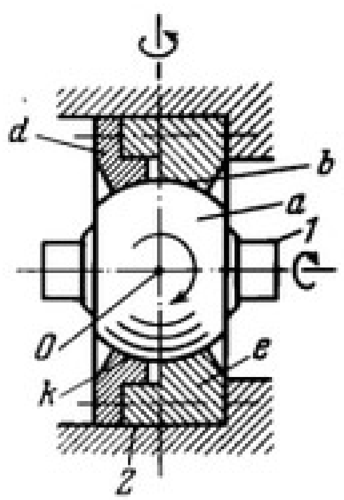


Link *1* ends in ball-shaped head *a* which fits into spherical socket *b* of link *2*. The pair is kept in geometrical contact by cover *d* which holds the head against link *2*. With respect to each other, links *1* and *2* accomplish three turning motions about three perpendicular axes intersecting in centre *O* of ball-shaped head *a*.

47

THREE-MOTION SPHERICAL KINEMATIC PAIR WITH A BARREL-SHAPED HEAD

EM
KP

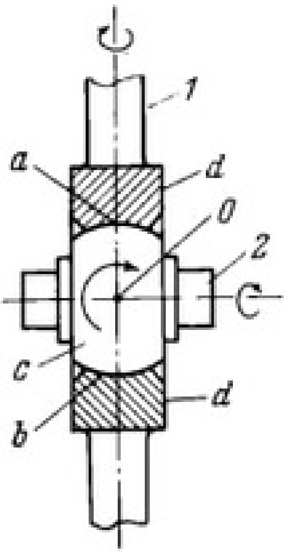


Link *1* has barrel-shaped spherical head *a* which fits into spherical collar *b* of link *2*. The pair is kept in geometrical contact by component *d* having spherical recess *k* which holds the head against component *e*. With respect to each other, links *1* and *2* accomplish three turning motions about three perpendicular axes intersecting in centre *O* of barrel-shaped head *a*.

48 THREE-MOTION SPHERICAL KINEMATIC PAIR WITH A SPHERICAL COLLAR

EM

KP



Link *1*, comprising two halves *a* and *b*, secured rigidly together, has spherical collar *d* fitting on spherical barrel-shaped head *c* of link *2*. With respect to each other, links *1* and *2* accomplish three turning motions about three perpendicular axes intersecting in centre *O* of barrel-shaped head *c*.

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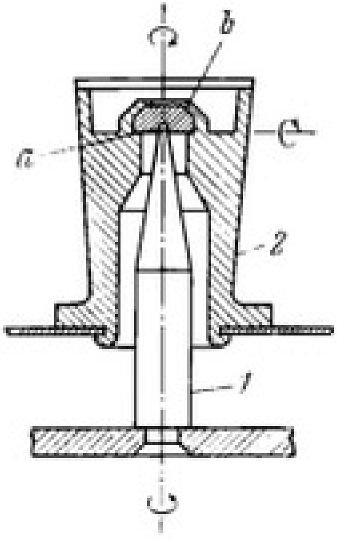
49 THREE-MOTION SPHERICAL KINEMATIC PAIR WITH A SUSPENDED LINK

EM

KP



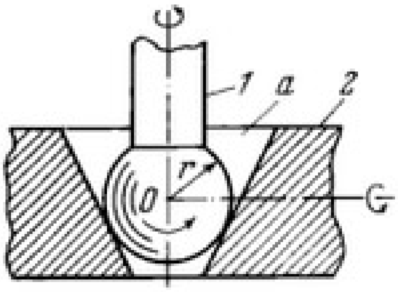
Link *1* ends in spherical tip *a* fitting into a spherical recess in component *b* of link *2*. With respect to link *2*, link *1* is thus in the suspended state providing for three turning motions about three perpendicular axes intersecting at the centre of the spherical surface of tip *a*.

50

THREE-MOTION SPHERICAL KINEMATIC PAIR WITH A CONICAL BEARING

EM

KP



Link 1 ends in a ball-shaped head of radius r which enters conical hole a of link 2, serving as the bearing for link 1. With respect to each other, links 1 and 2 accomplish three turning motions about three arbitrarily selected perpendicular axes passing through point O, the centre of the ball-shaped head of radius r.

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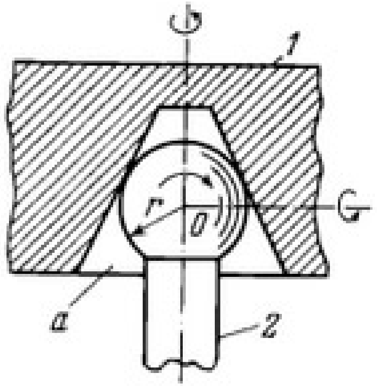
51

THREE-MOTION SPHERICAL KINEMATIC PAIR WITH A BALL-SHAPED BEARING

EM

KP



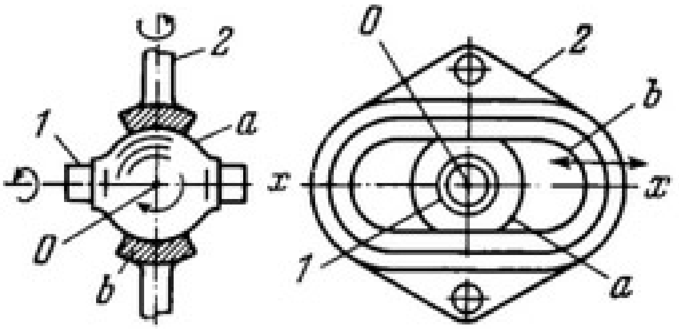
Link 1 has conical recess a which fits over and contacts the ball-shaped head of radius r on the end of link 2 serving as the bearing for link 1. With respect to each other, links 1 and 2 accomplish three turning motions about three arbitrarily selected axes passing through point O, the centre of the ball-shaped head of radius r.

52

FOUR-MOTION KINEMATIC PAIR WITH A BARREL-SHAPED HEAD

EM

KP



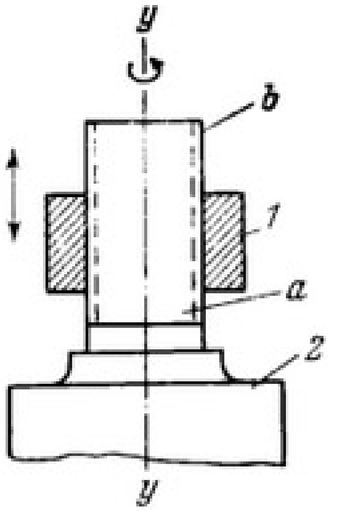
Link *1* has barrel-shaped spherical head *a* fitting into collar *b* of circular cross section and spherical ends. Collar *b* is a part of link *2*. With respect to each other, links *1* and *2* accomplish three turning motions about three perpendicular axes intersecting at centre *O* of barrel-shaped head *a*, and one translational motion along axis *x-x* of collar *b*.

53

SINGLE-MOTION SCREW KINEMATIC PAIR

EM

KP

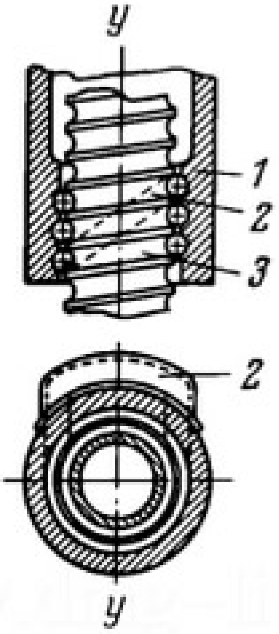


Links *1* and *2* have screw threads *a* and *b* of constant pitch. With respect to each other, links *1* and *2* accomplish a helical motion about and along common axis *y-y*.

54

SINGLE-MOTION BALL-BEARING SCREW KINEMATIC PAIR

EM
KP

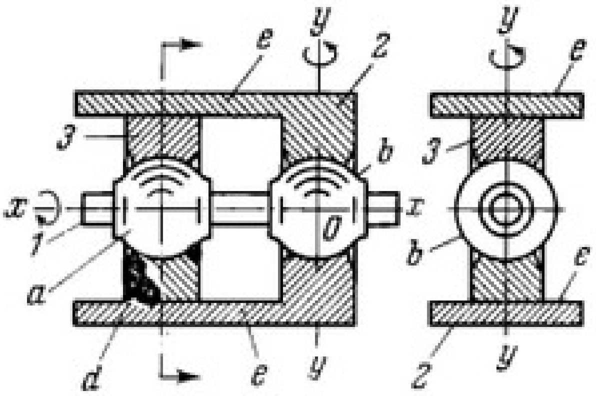


Link *1*, which is the ball-bearing nut, has recirculating channel *2* filled with balls. As ball-bearing screw, link *3*, is screwed into link *1*, the balls roll along the thread which is in the form of semi-circular grooves in both the nut and screw. At the end of the nut the balls run back into recirculating channel *2* and through it to the beginning of the nut again. Thus sliding friction is replaced by rolling friction, thereby substantially raising the efficiency of the screw. With respect to each other, links *1* and *3* accomplish a helical motion about and along common axis *y*-*y*.

2. MOVABLE JOINTS (55 through 119)

55 TWO-MOTION JOINT WITH AN INTERMEDIATE SLIDING MEMBER

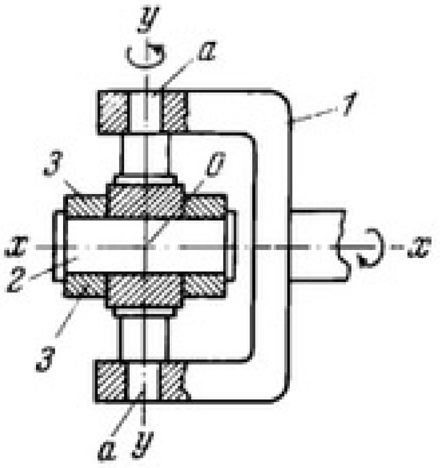
EM
MJ



Link *1* has two ball-shaped heads, *a* and *b*. Head *a* fits into spherical collar *d* of sliding member *3* which slides between flat surfaces *e* of link *2*. With respect to each other, links *1* and *2* accomplish two turning motions about two perpendicular axes, *x-x* and *y-y*, intersecting at point *O*.

56 TWO-MOTION JOINT WITH AN INTERMEDIATE CROSS-SHAPED BUSHING

EM
MJ

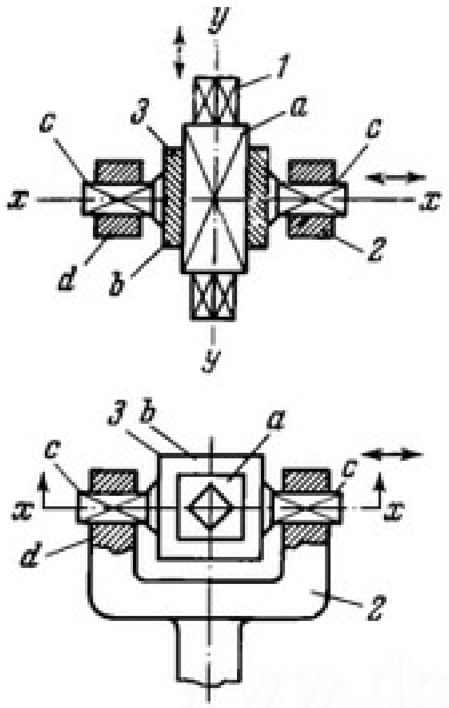


Link *1* is connected by a turning pair to cross-shaped bushing *3* which has cylindrical trunnions *a*. Link *2* rotates freely in bushing *3*. With respect to each other, links *1* and *2* accomplish two turning motions about two perpendicular axes, *x-x* and *y-y*, intersecting at point *O*.

57

TWO-MOTION JOINT WITH TWO PRISMATIC SLIDING MEMBERS

EM
MJ

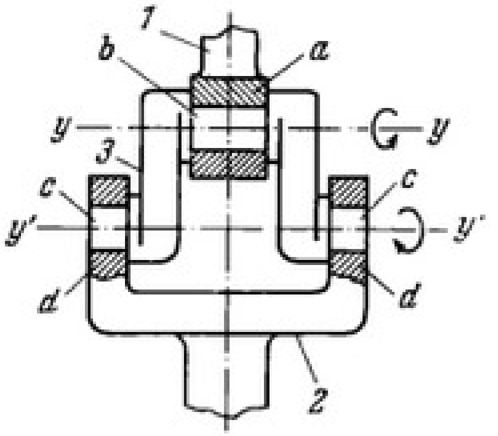


Link *1* has prismatic sliding member *a* moving along square guide *b* of link *3*. Link *3* has prismatic sliding members *c* moving along guides *d* of link *2*. With respect to each other, links *1* and *2* accomplish two translational motions along perpendicular axes *x-x* and *y-y*.

58

TWO-MOTION JOINT OF A DOUBLE PENDULUM

EM
MJ

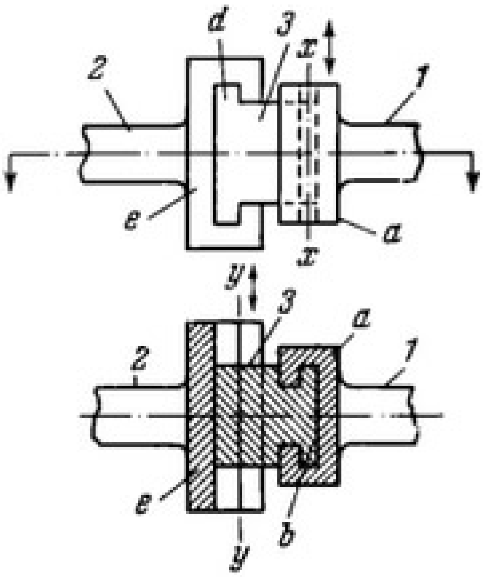


Link *1* has eye *a* turning about pin *b* of link *3*. Link *3* has trunnions *c* turning in holes *d* of link *2*. With respect to each other, links *1* and *2* accomplish two turning motions about parallel axes *y-y* and *y'-y'*.

59

TWO-MOTION JOINT WITH A DOUBLE INTERMEDIATE T-SLOT BLOCK

EM
MJ

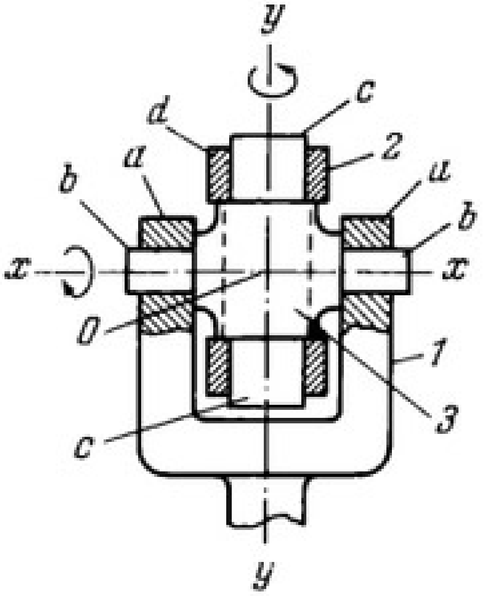


Link *1* has T-slot guide *a* along which one T-shaped end *b* of T-slot block *3* slides. The other end *d* of block *3* slides along T-slot guide *e* of link *2*. With respect to each other, links *1* and *2* accomplish two translational motions along perpendicular axes *x-x* and *y-y*.

60

TWO-MOTION JOINT WITH AN INTERMEDIATE CROSS-SHAPED LINK

EM
MJ



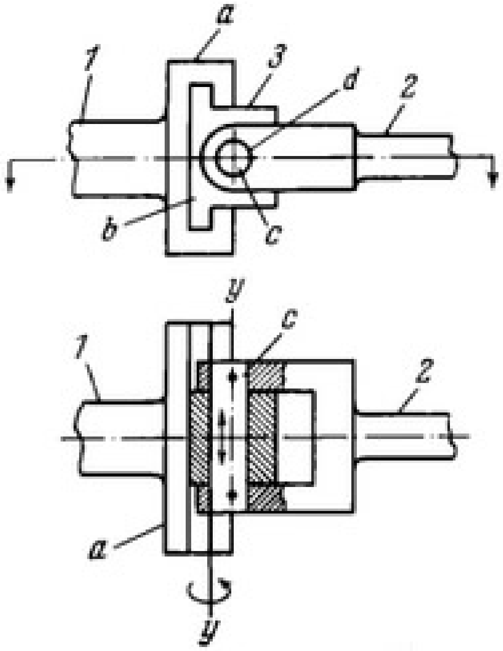
Link *1* has two holes *a* into which trunnions *b* of cross-shaped link *3* fit. Trunnions *c* of link *3* fit into holes *d* of link *2*. With respect to each other, links *1* and *2* accomplish two turning motions about two perpendicular axes, *x-x* and *y-y*, intersecting at point *O*.

61

TWO-MOTION JOINT WITH A T-SLOT GUIDE

EM

MJ



Link *1* has T-slot guide *a* along which T-shaped end *b* of sliding member *3* slides. Secured to link *2* is pin *c* which fits into hole *d* of sliding member *3*. With respect to each other, links *1* and *2* accomplish one turning and one translational motion about and along axis *y-y*.

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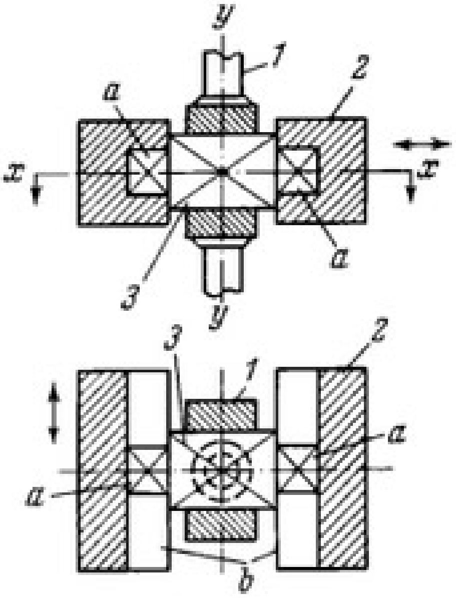
62

TWO-MOTION JOINT WITH AN INTERMEDIATE PRISMATIC SLIDING MEMBER

EM

MJ



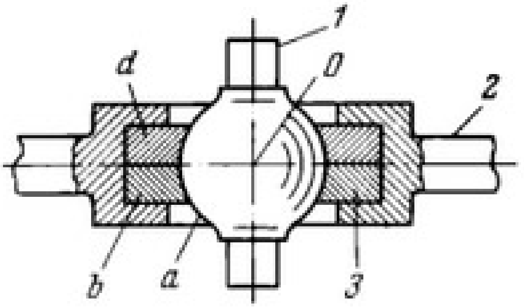
Link *1* slides along prismatic sliding member *3* which has two rectangular lugs *a* that slide along guides *b* in link *2*. With respect to each other, links *1* and *2* accomplish two translational motions along the perpendicular axes, *x-x* and *y-y*.

63

THREE-MOTION JOINT WITH AN INTERMEDIATE YOKE

EM

MJ



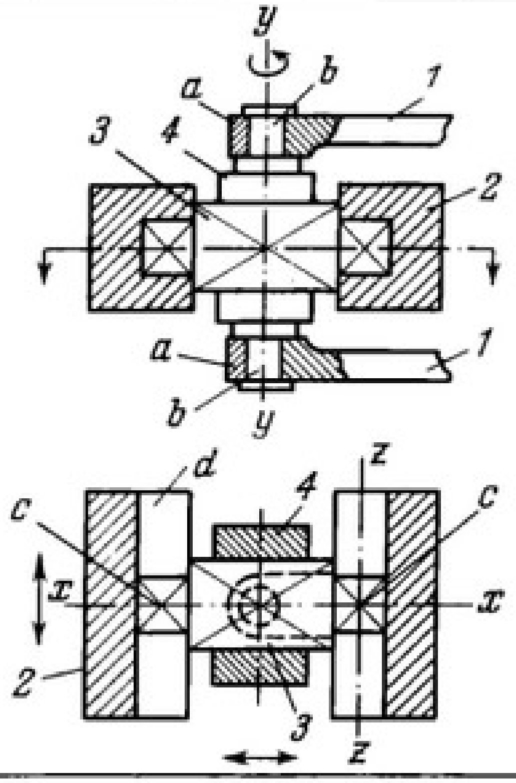
Link *1* has spherical head *a* fitting into yoke *3* which consists of halves *b* and *d*, secured rigidly together. Yoke *3* is held in the collar of link *2*. With respect to each other, links *1* and *2* accomplish three turning motions about three perpendicular axes intersecting at point *O*.

64

THREE-MOTION JOINT WITH TWO INTERMEDIATE SLIDING MEMBERS

EM

MJ

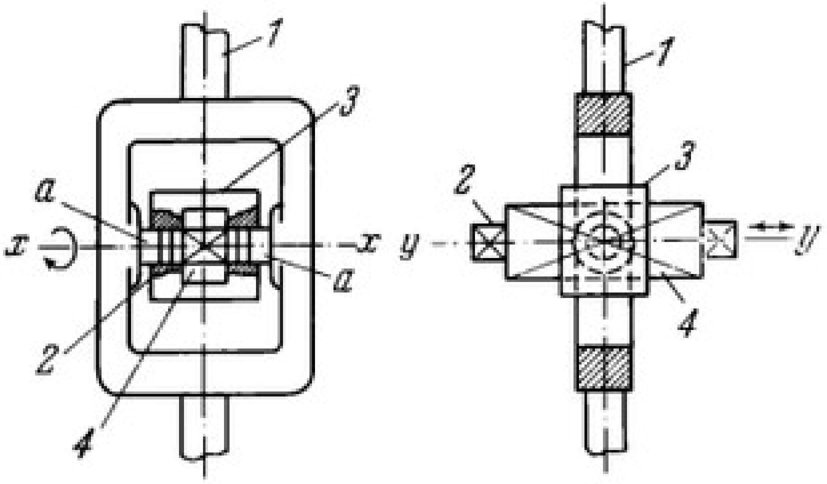


Link *1* has holes *a* into which trunnions *b* of sliding member *4* fit. Sliding member *4* travels along sliding member *3* which has two lugs *c* that slide along guides *d* of link *2*. With respect to each other, links *1* and *2* accomplish one turning motion about axis *y-y*, and two translational motions along axes *x-x* and *z-z*.

65

THREE-MOTION JOINT WITH THREE COAXIAL SLIDING MEMBERS

EM
MJ

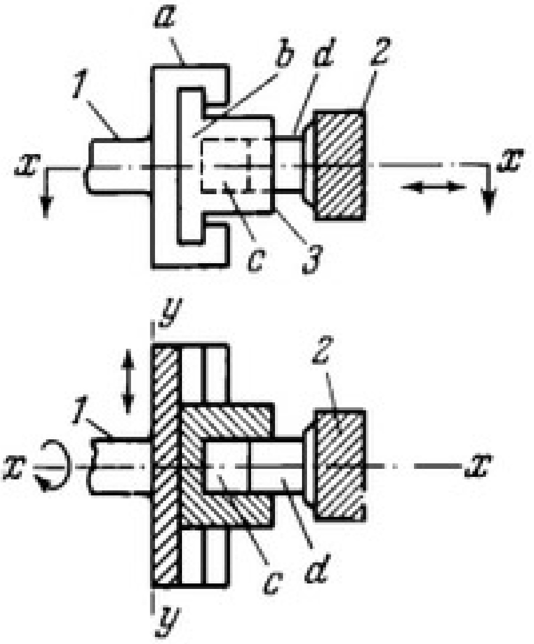


Link *1*, designed as a frame, has trunnions *a* fitting into holes of link *3*. Link *3* slides along coaxial link *4* which, in its turn, slides along link *2*. With respect to each other, links *1* and *2* accomplish one turning motion about axis *x-x* and two translational motions along common axis *y-y* of links *2*, *3* and *4*.

66

THREE-MOTION JOINT WITH A T-SLOT BLOCK

EM
MJ

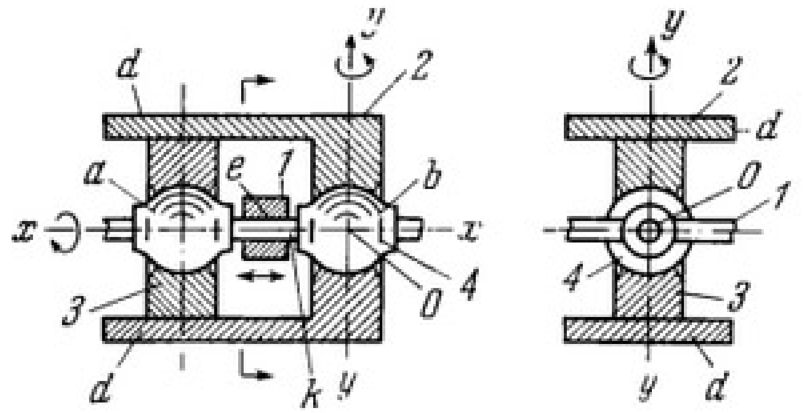


Link *1* has T-slot guide *a* in which T-shaped end *b* of block *3* slides. Block *3* has cylindrical recess *c* into which round pin *d* of link *2* fits. With respect to each other, links *1* and *2* accomplish one turning motion about axis *x-x* and two translational motions along the perpendicular axes *x-x* and *y-y*.

67

THREE-MOTION JOINT WITH AN INTERMEDIATE SLIDING MEMBER

EM
MJ

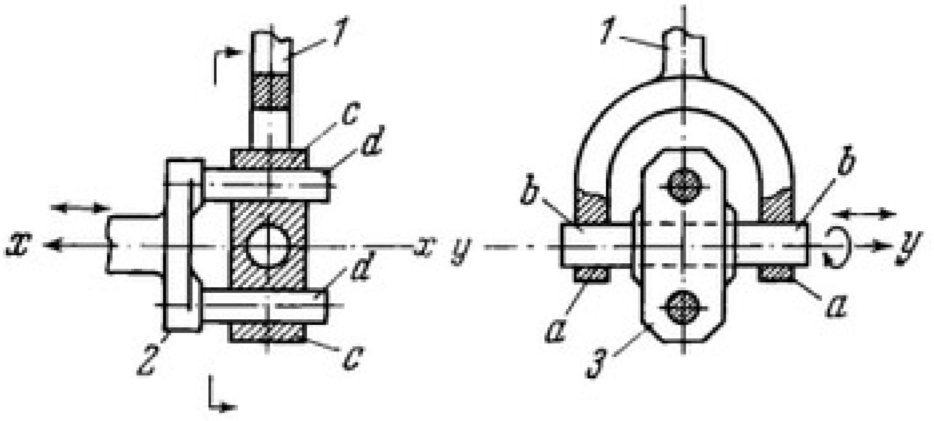


Link *1* has hole *e* fitting on cylindrical portion *k* of link *4*, which has two ball-shaped heads *a* and *b*. Head *a* fits into sliding member *3* and head *b* into link *2*. Sliding member *3* moves between flat surfaces *d* of link *2*. With respect to each other, links *1* and *2* accomplish two turning motions about perpendicular axes *x-x* and *y-y*, and one translational motion along axis *x-x*.

68

THREE-MOTION JOINT WITH AN INTERMEDIATE TRUNNION-TYPE SLIDING MEMBER

EM
MJ

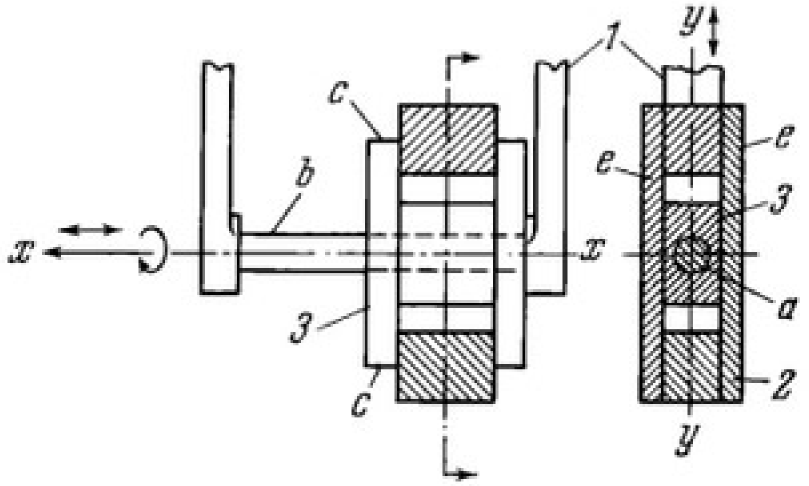


Link *1* has holes *a* into which trunnions *b* of sliding member *3* fit. Sliding member *3* has holes *c* into which pins *d* of link *2* fit. With respect to each other, links *1* and *2* accomplish one turning motion about axis *y-y*, and two translational motions along perpendicular axes *x-x* and *y-y*.

69

THREE-MOTION JOINT WITH AN INTERMEDIATE SLIDING MEMBER

EM
MJ

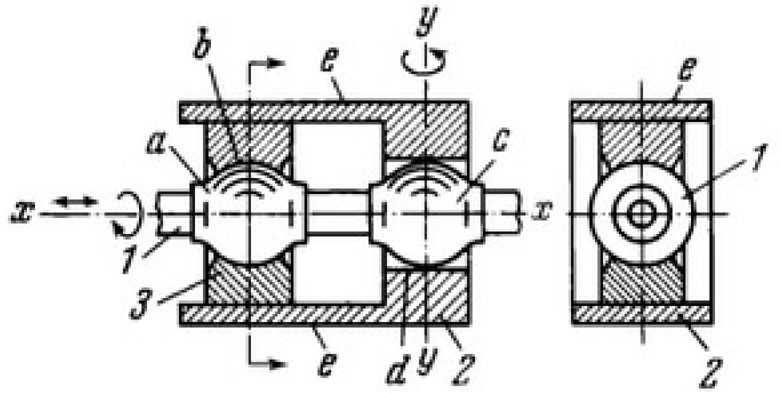


Link *1* has pin *b* fitting into hole *a* of sliding member *3*. Sliding member *3* slides between two plates *e* of link *2*. Flanges *c* of sliding member *3* prevent it from tipping over between its guide plates. With respect to each other, links *1* and *2* accomplish one turning motion about axis *x-x* and two translational motions along perpendicular axes *x-x* and *y-y*.

70

THREE-MOTION JOINT WITH BALL-SHAPED HEADS

EM
MJ

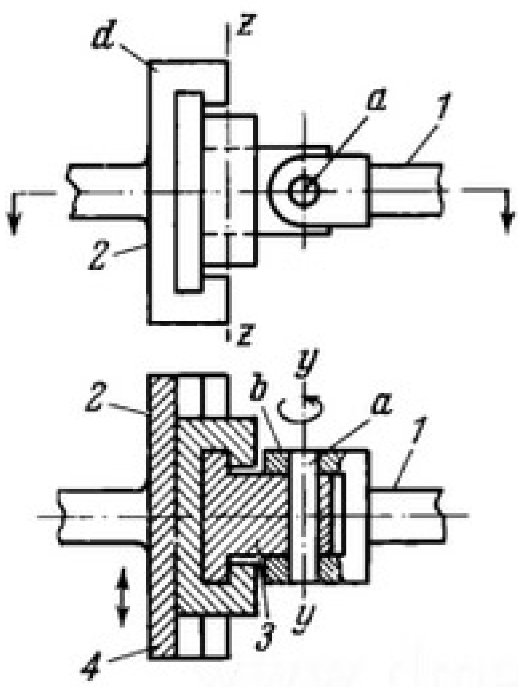


Link *1* has two ball-shaped heads, *a* and *c*. Head *a* fits into spherical collar *b* of link *3*. Head *c* fits into cylindrical hole *d* of link *2*. Link *3* slides between flat surfaces *e* of link *2*. With respect to each other, links *1* and *2* accomplish two turning motions about perpendicular axes *x-x* and *y-y*, and one translational motion along axis *x-x*.

71

THREE-MOTION JOINT WITH A T-SLOT BLOCK

EM
MJ

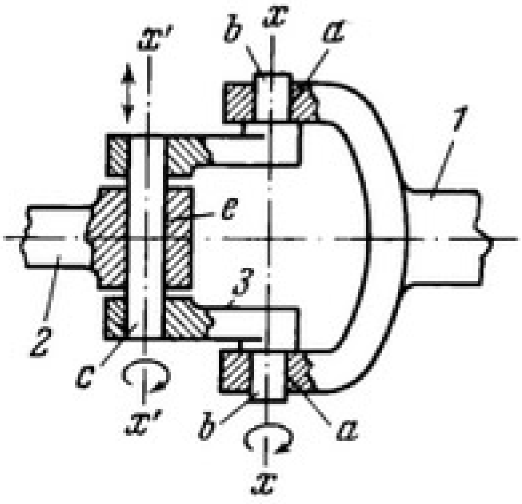


Link *1* has pin *a* fitting into hole *b* of sliding member *3*. Sliding member *3* moves in T-slot block *4* which, in its turn, slides in T-slot guide *d* of link *2*. With respect to each other, links *1* and *2* accomplish one turning motion about axis *y-y* and two translational motions along perpendicular axes *y-y* and *z-z*.

72

THREE-MOTION JOINT WITH AN INTERMEDIATE CRANK

EM
MJ



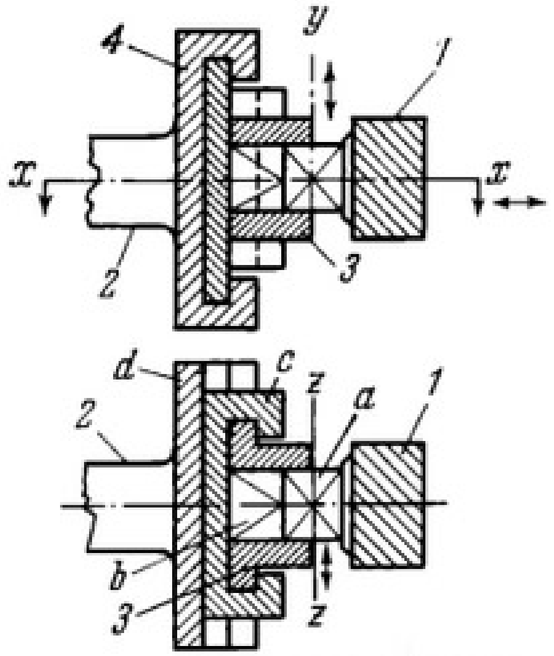
Trunnions *b* of link *3* fit into holes *a* of link *1*. Pin *c* of link *3* fits into hole *e* of link *2*. With respect to each other, links *1* and *2* accomplish two turning motions about parallel axes *x-x* and *x'-x'*, and one translational motion along axis *x'-x'*.

73

THREE-MOTION JOINT WITH THREE SLIDING MEMBERS

EM

MJ



Link *1* has lug *a* which slides in guide *b* of sliding member *3*. Sliding member *3* slides in T-slot guide *c* of sliding member *4* which, in its turn, slides in T-slot guide *d* of link *2*. With respect to each other, links *1* and *2* accomplish three translational motions along three perpendicular axes, *x-x*, *y-y* and *z-z*.

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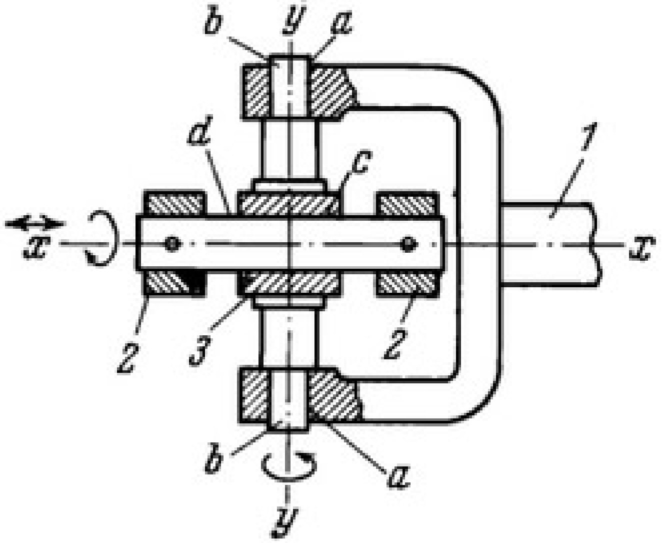
74

THREE-MOTION JOINT WITH AN INTERMEDIATE CROSSHEAD

EM

MJ

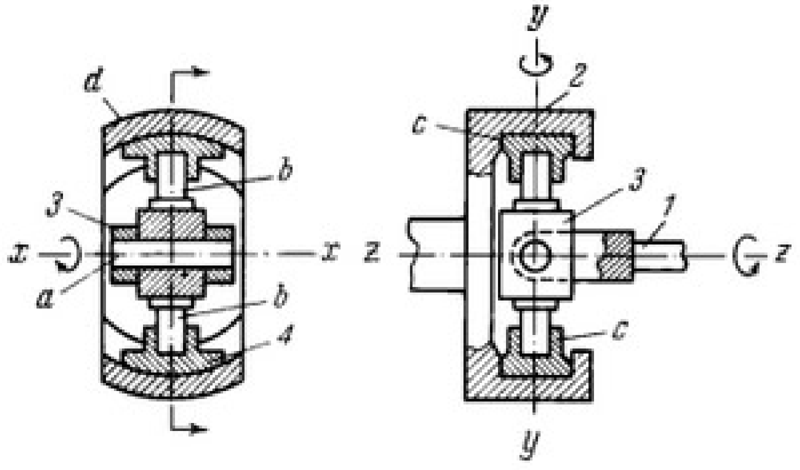


Trunnions *b* of crosshead *3* fit into holes *a* of link *1*. Pin *d* of link *2* fits into hole *c* of crosshead *3*. With respect to each other, links *1* and *2* accomplish two turning motions about perpendicular axes *x-x* and *y-y*, and one translational motion along axis *x-x*.

75 THREE-MOTION JOINT WITH AN INTERMEDIATE RING

EM

MJ

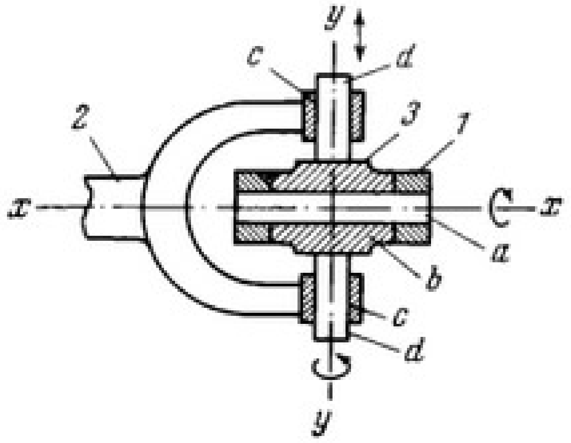


Pin *a* of link *1* turns in a hole of component *3* which has trunnions *b* that fit into holes in shoes *c* (link *4*). These shoes slide along an annular slot in housing *d* of link *2*. With respect to each other, links *1* and *2* accomplish three turning motions about perpendicular axes *x-x*, *y-y* and *z-z*.

76 THREE-MOTION JOINT WITH AN INTERMEDIATE PIN

EM

MJ



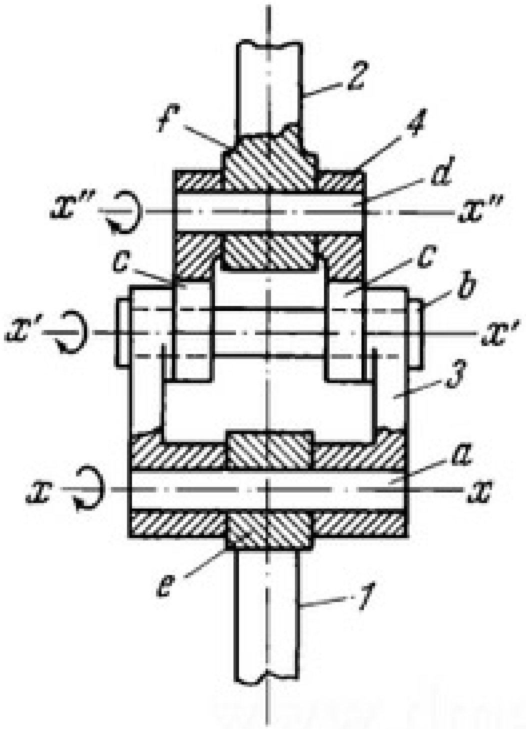
Link *1*, of exactly the same shape as link *2*, is secured to pin *a* which turns in the hole of crosspiece *b* (link *3*). Trunnions *d* of link *3* fit into holes *c* of link *2*. With respect to each other, links *1* and *2* accomplish two turning motions about perpendicular axes *x-x* and *y-y*, and one translational motion along axis *y-y*.

77

THREE-MOTION JOINT OF A TRIPLE PENDULUM

EM

MJ



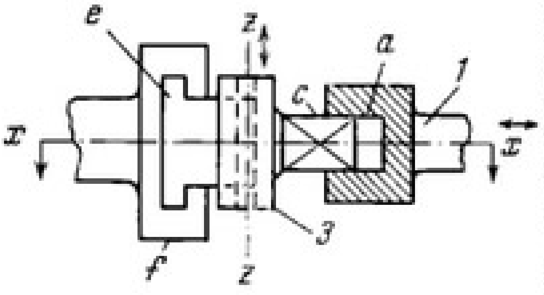
Pin *a* of link *3* fits into the hole in eye *e* of link *1*. Pin *b* of link *3* fits into eyes *c* of link *4*. Pin *d* of link *4* fits into the hole in eye *f* of link *2*. With respect to each other, links *1* and *2* accomplish three turning motions about parallel axes *x-x*, *x′-x′* and *x″-x″*.

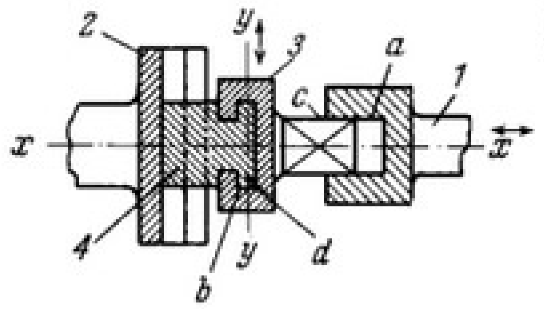
78

THREE-MOTION JOINT WITH THREE SLIDING MEMBERS

EM

MJ



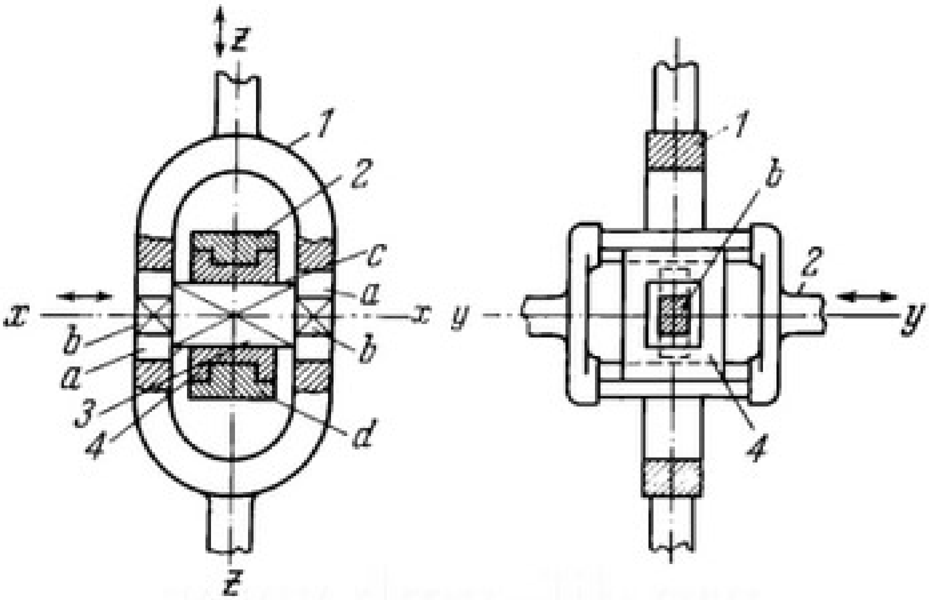


Sliding member *c* of link *3* slides along rectangular guide *a* of link *1*. T-shaped head *d* of link *4* slides along T-slot guide *b* of link *3*. T-shaped head *e* of link *4* slides along T-slot guide *f* of link *2*. With respect to each other, links *1* and *2* accomplish three translational motions along perpendicular axes *x-x*, *y-y* and *z-z*.

79

THREE-MOTION JOINT WITH THREE SLIDING MEMBERS

EM
MJ



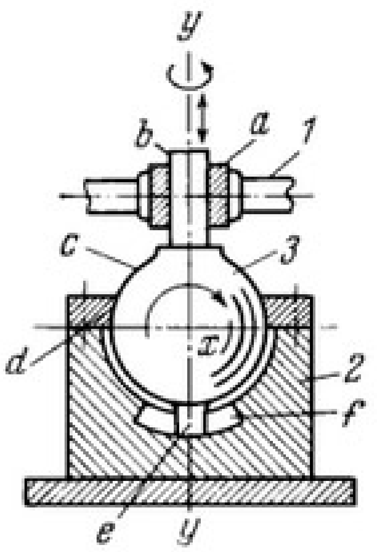
Two trunnions *b* of square cross section slide along rectangular slot guides *a* of link *1*. Link *4* with its rectangular hole slides along rectangular pin guide *c* of link *3*. Link *2* slides along guides *d* of link *4*. With respect to each other, links *1* and *2* accomplish three translational motions along axes *x-x*, *y-y* and *z-z*.

80

THREE-MOTION JOINT WITH A LUG IN A CIRCULAR GROOVE

EM

MJ



Rod *b* of link *3* fits into bushing *a* of link *1*. Link *3* has spherical surface *c* fitting into spherical collar *d* of link *2*. Link *3* has round lug *e* which slides along circular groove *f* of link *2*. With respect to each other, links *1* and *2* accomplish two turning motions about perpendicular axes *x-x* and *y-y*, and one translational motion along axis *y-y*.

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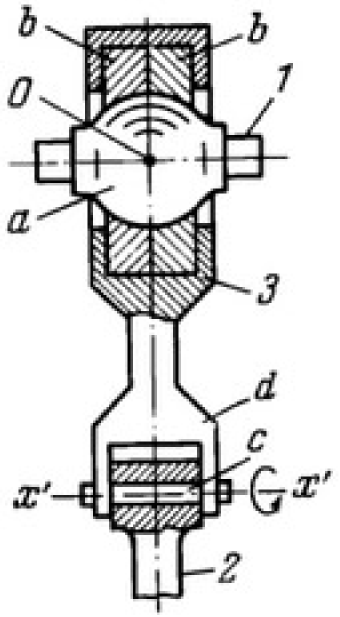
81

FOUR-MOTION JOINT WITH A BALL-SHAPED HEAD

EM

MJ



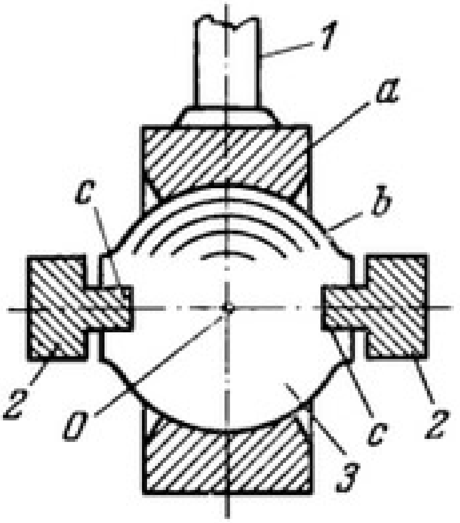
Link *1* has ball-shaped head *a* fitting into two spherical half-collars *b* of link *3*. Link *3* has, at its other end, clevis *d* in which pin *c* is secured. Link *2* turns about axis *x'-x'* of pin *c*. With respect to each other, links *1* and *2* accomplish four turning motions about three perpendicular axes intersecting at point *O* and about axis *x'-x'*.

82

FOUR-MOTION JOINT WITH A SLOTTED BALL-SHAPED HEAD

EM

MJ



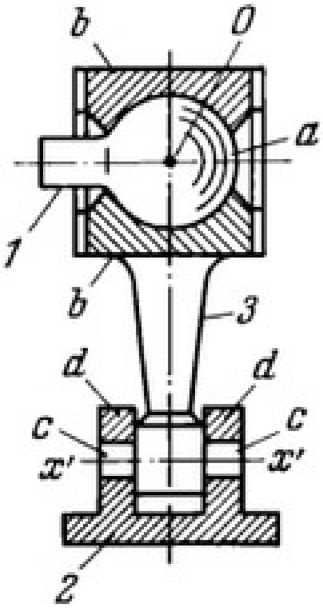
Link *1* has spherical collar *a* fitting over ball-shaped head *b* of link *3*. Guide flanges *c* of link *2* fit into slots at the sides of ball-shaped head *b*. With respect to each other, links *1* and *2* accomplish three turning motions about the three perpendicular axes intersecting at point *O* and one translational motion along guide flanges *c*.

83

FOUR-MOTION JOINT WITH A BALL-SHAPED HEAD

EM

MJ



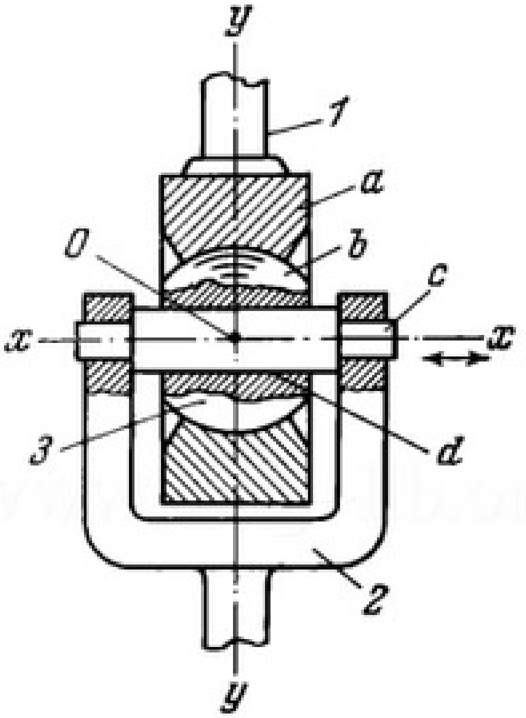
Link *1* has ball-shaped head *a* fitting into spherical half-collars *b* of link *3*. Trunnions *c* at the other end of link *3* fit into holes *d* of link *2*. With respect to each other, links *1* and *2* accomplish four turning motions about the three perpendicular axes intersecting at point *O* and about axis *x'-x'*.

84

FOUR-MOTION JOINT WITH A BALL-SHAPED LINK

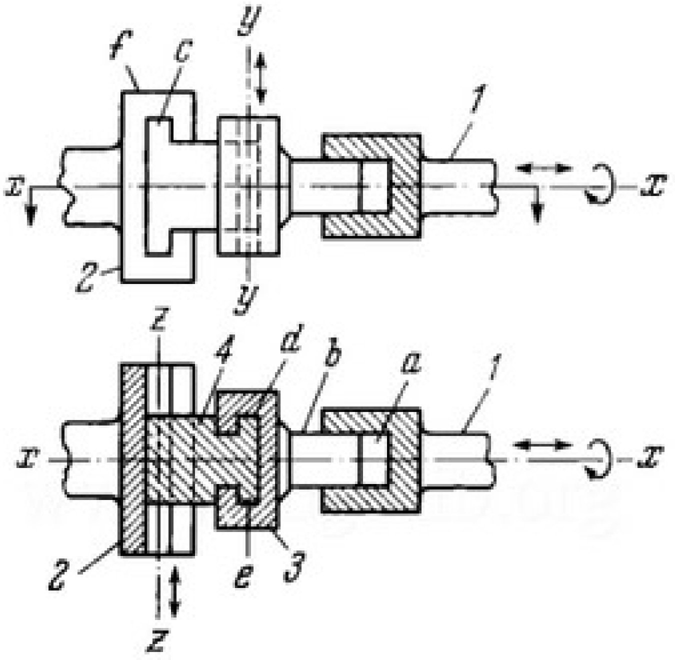
EM

MJ



Link *1* has spherical half-collars *a* fitting over ball-shaped link *3*. Pin *c* of link *2* fits into hole *d* of link *3*. With respect to each other, links *1* and *2* accomplish three turning motions about the perpendicular axes intersecting at point *O* and one translational motion along axis *x-x*.

FOUR-MOTION JOINT WITH T-SLOT GUIDES



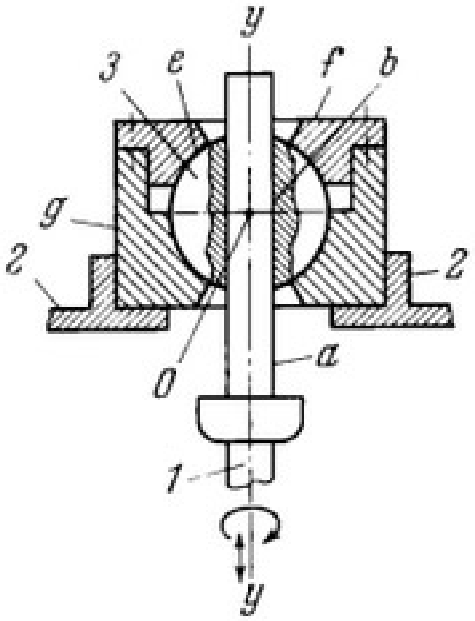
Round pin *b* of link *3* fits into round recess *a* of link *1*. One T-shaped end *e* of link *4* slides along T-slot guide *d* of link *3*. The other T-shaped end *c* of link *4* slides along T-slot guide *f* of link *2*. With respect to each other, links *1* and *2* accomplish one turning motion about axis *x-x*, and three translational motions along perpendicular axes *x-x*, *y-y* and *z-z*.

86

FOUR-MOTION JOINT WITH A BALL-SHAPED LINK

EM

MJ



Link *1* has round rod *a* fitting into hole *b* of ball-shaped link *3*. Spherical surface *e* of link *3* fits into spherical bearing *g* in which it is held by cover *f* having spherical collar *e*. With respect to each other, links *1* and *2* accomplish three turning motions about the three perpendicular axes intersecting at point *O*, and one translational motion along axis *y*-*y*.

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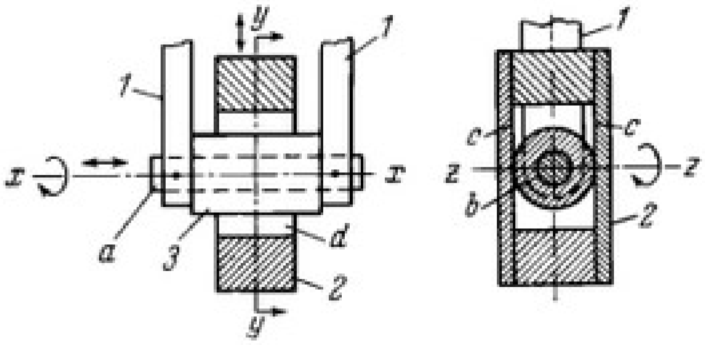
87

FOUR-MOTION JOINT WITH A PLANE GUIDE

EM

MJ

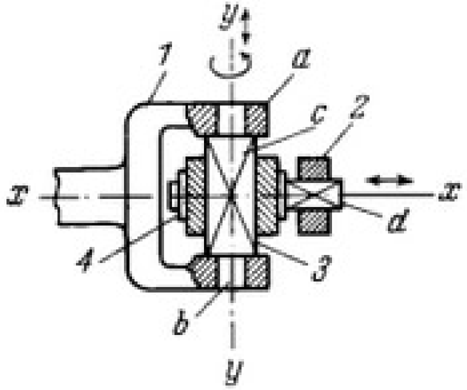


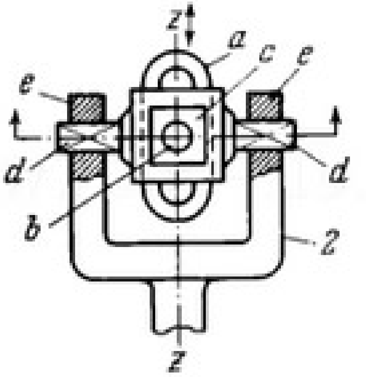
Link *1* has pin *a* fitting into hole *b* of link *3* which is of circular cylindrical shape. Inner flat surfaces *c* of the side walls of link *2* form plane guide *d*. With respect to each other, links *1* and *2* accomplish two turning motions about perpendicular axes *x*-*x* and *z*-*z*, and two translational motions along axes *x*-*x* and *y*-*y*.

88

FOUR-MOTION JOINT WITH OVAL GUIDES

EM
MJ





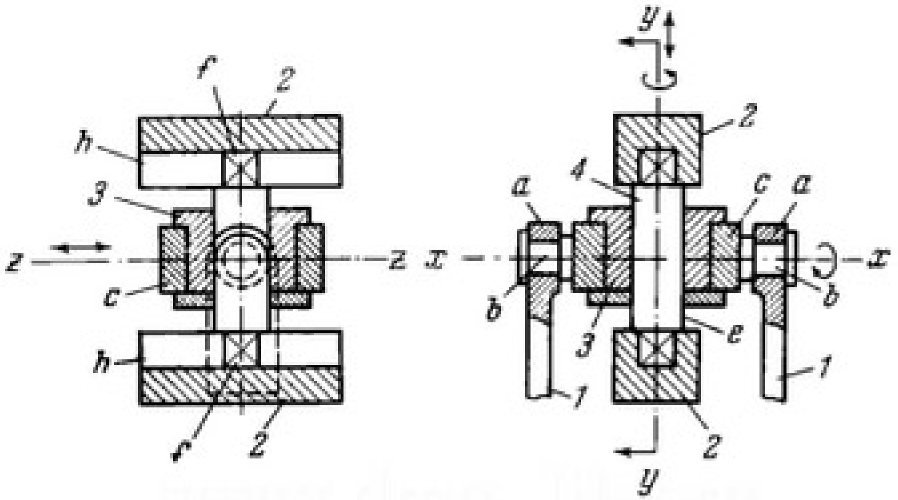
Round trunnions *b* of link *3* turn and slide along oval guides *a* of link *1*. Square body *c* of link *2* fits into the square hole of link *4* which has square trunnions *d*. Link *2* has prongs *e* with square holes sliding along trunnions *d*. With respect to each other, links *1* and *2* accomplish one turning motion about axis *y-y*, and three translational motions along perpendicular axes *x-x*, *y-y* and *z-z*.

89

FOUR-MOTION JOINT WITH A CYLINDRICAL GUIDE

FM

MJ



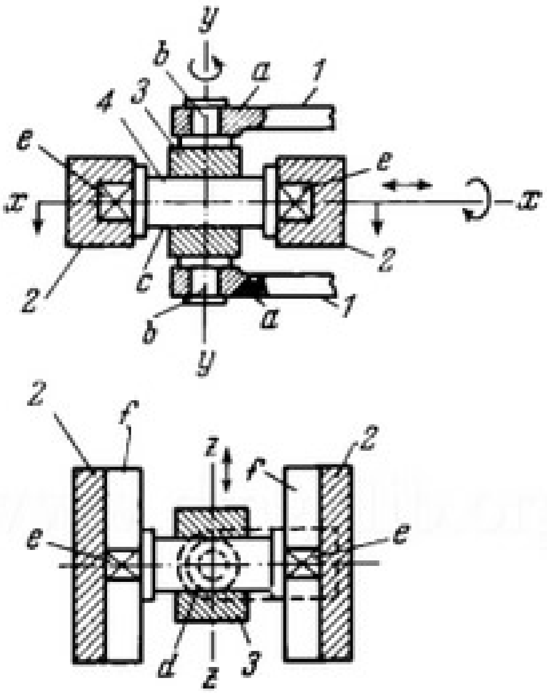
Trunnions *b* of ring *c* of link *3* fit into round holes *a* of the prongs of link *1*. The inner part of link *3*, in the form of a bushing, fits over cylindrical guide *e* of link *4*. Square trunnions *f* at the ends of link *4* slide along guide slots *h* of link *2*. With respect to each other, links *1* and *2* accomplish two turning motions about perpendicular axes *x-x* and *y-y*, and two translational motions along perpendicular axes *y-y* and *z-z*.

90

FOUR-MOTION JOINT WITH A ROUND GUIDE

EM

MJ



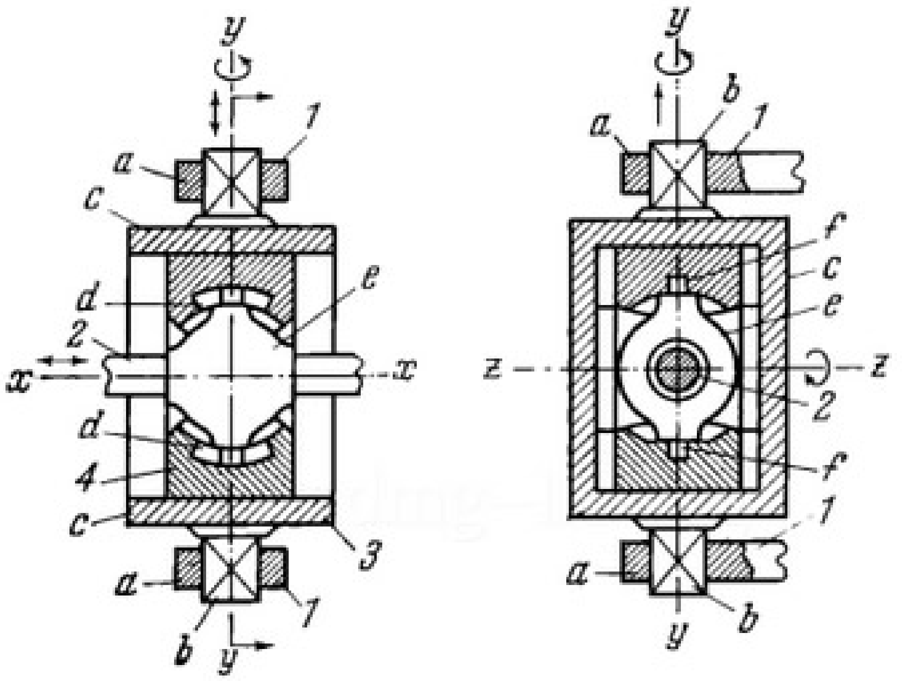
Round trunnions *b* of link *3* fit into holes in prongs *a* of link *1*. Hole *d* of link *3* fits over round guide *c* of link *4*. Square trunnions *e* at the ends of link *4* slide along guide slots *f* of link *2*. With respect to each other, links *1* and *2* accomplish two turning motions about perpendicular axes *x-x* and *y-y*, and two translational motions along perpendicular axes *x-x* and *z-z*.

91

FOUR-MOTION JOINT WITH A HEAD HAVING LUGS

EM

MJ



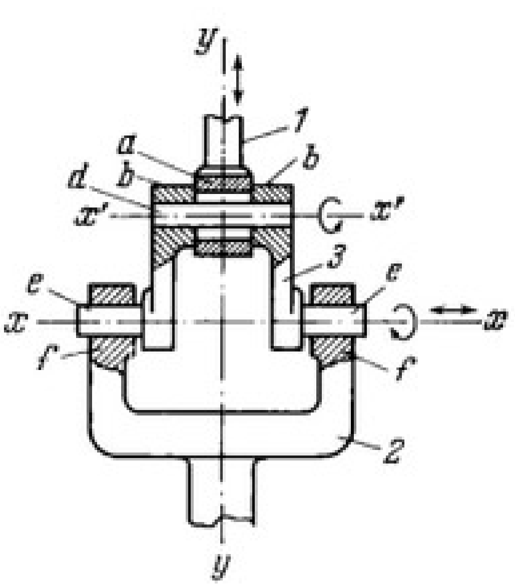
Square trunnions *b* of link *3* fit into square holes in prongs *a* of link *1*. Link *3* has box-shaped guide *c* in which link *4* slides. Lugs *f* on lug-type head *e* of link *2* slide along circular grooves *d* inside link *4*. With respect to each other, links *1* and *2* accomplish two turning motions about perpendicular axes *y-y* and *z-z*, and two translational motions along perpendicular axes *x-x* and *y-y*.

92

FOUR-MOTION JOINT WITH AN EYE HAVING LARGE CLEARANCE

EM

MJ



Eye *a* of link *1* fits with a large clearance over pin *d* of link *3*. Eye *a* slides between cheeks *b* of link *3*, its motion being limited by pin *d*. Link *3* has trunnions *e* fitting into holes in prongs *f* of link *2*. With respect to each other, links *1* and *2* accomplish two turning motions about parallel axes *x-x* and *x′-x′*, and two translational motions along perpendicular axes *x-x* and *y-y*.

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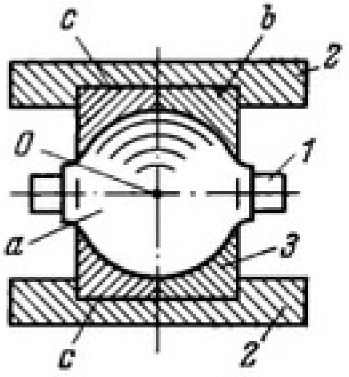
93

FOUR-MOTION JOINT WITH A BALL-SHAPED HEAD

EM

MJ

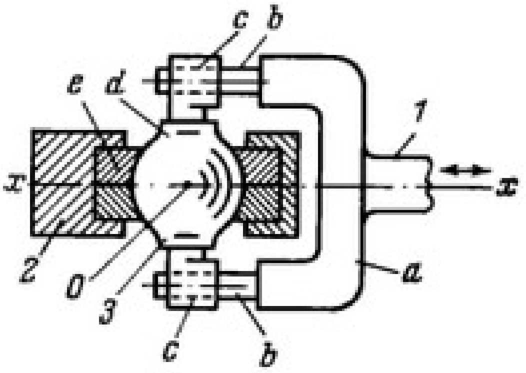


Link *1* has ball-shaped head *a* fitting into spherical half-collars *b* of link *3*. Link *3* slides along guide slots *c* of link *2*. With respect to each other, links *1* and *2* accomplish three turning motions about the perpendicular axes intersecting at point *O*, and one translational motion along an axis square to the plane of the drawing.

94

FOUR-MOTION JOINT WITH A PIN-TYPE FORK

EM
MJ



Link *1* has pin-type fork *a* with pins *b* fitting into holes *c* in the lugs of link *3*. Link *3* has ball-shaped head *d* fitting into spherical half-collars *e* of link *2*. With respect to each other, links *1* and *2* accomplish three turning motions about the perpendicular axes intersecting at point *O*, and one translational motion along axis *x-x*.

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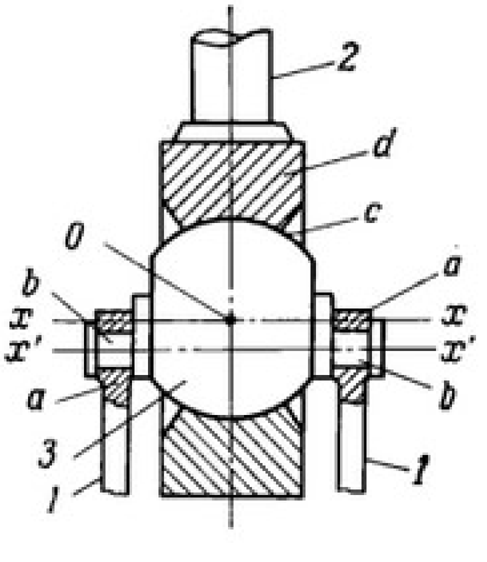
95

FOUR-MOTION JOINT WITH A BARREL-SHAPED HEAD

EM
MJ

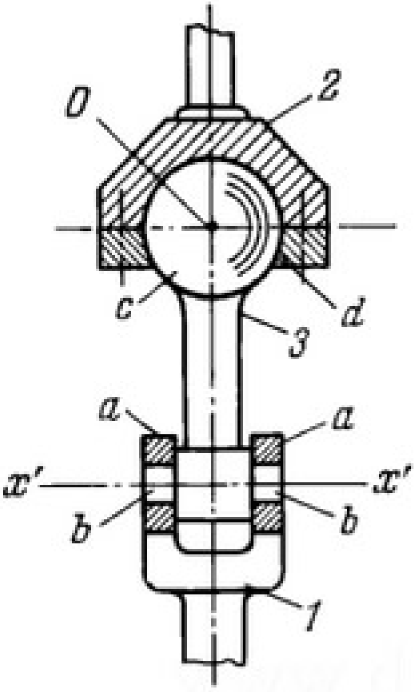


Round trunnions *b* of barrel-shaped head *3* fit in holes in prongs *a* of link *1*. Head *3* has spherical surface *c* fitting into half-collars *d* of link *2*. With respect to each other, links *1* and *2* accomplish four turning motions about the three perpendicular axes intersecting at point *O* and about axis *x'-x'*.

96

FOUR-MOTION JOINT WITH A BALL-SHAPED HEAD

EM
MJ



Round trunnions *b* of link *3* fit into holes in clevis *a* of link *1*. Ball-shaped head *c* at the other end of link *3* fits into spherical recess *d* of link *2*. With respect to each other, links *1* and *2* accomplish four turning motions about the three perpendicular axes intersecting at point *O* and about axis *x'-x'*.

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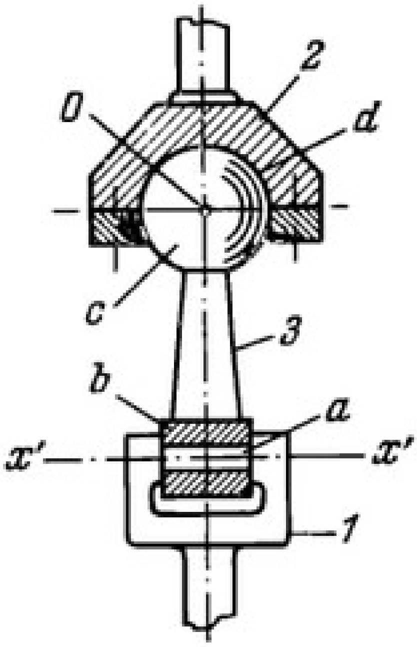
97

FOUR-MOTION JOINT WITH A BALL-SHAPED HEAD

EM
MJ



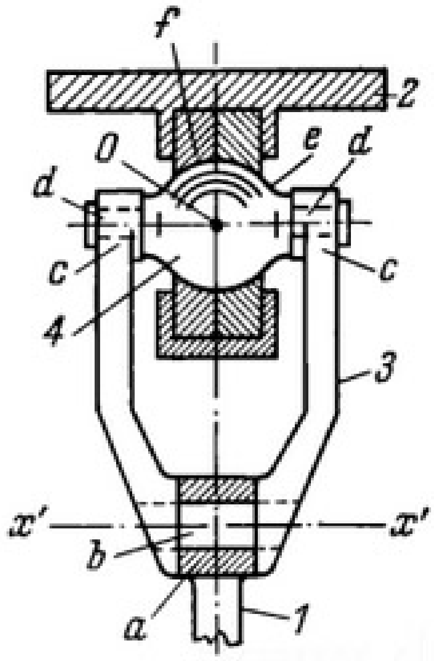
Link *1* has round pin *a* fitting into a hole in head *b* of link *3*. Ball-shaped head *c* at the other end of link *3* fits into spherical recess *d* of link *2*. With respect to each other, links *1* and *2* accomplish four turning motions about the three perpendicular axes intersecting at point *O* and about axis *x'-x'*.

98

FOUR-MOTION JOINT WITH AN INTERMEDIATE FORK

EM

MJ



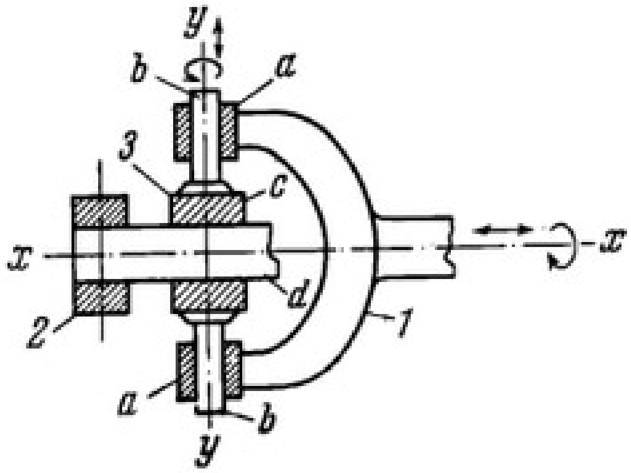
Pin *b* of link *3* fits into the hole in head *a* of link *1*. Round trunnions *d* of link *4* fit into holes in prongs *c* of fork-shaped link *3*. Barrel-shaped spherical surface *e* of link *4* fits into spherical half-collars *f* of link *2*. With respect to each other, links *1* and *2* accomplish four turning motions about the three perpendicular axes intersecting at point *O* and about axis *x′*-*x′*.

99

FOUR-MOTION JOINT WITH A CYLINDRICAL GUIDE

EM

MJ

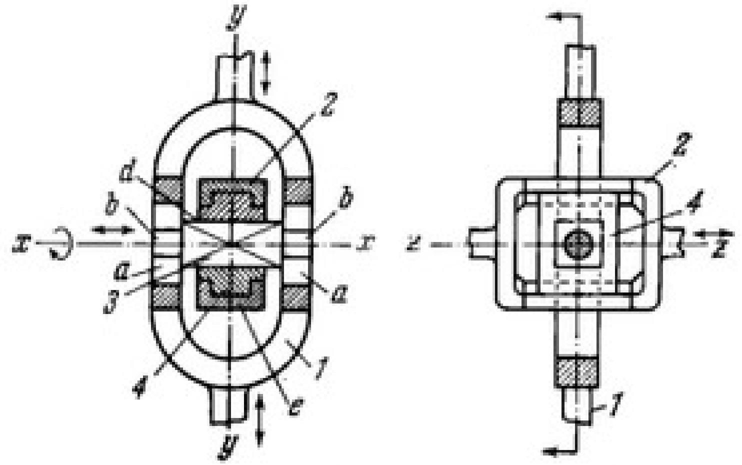


Pins *b* of link *3* fit into holes in prongs *a* of link *1*. Cylindrical guide *d* of link *2* fits into the hole in body *c* of link *3*. With respect to each other, links *1* and *2* accomplish two turning motions and two translational motions about and along perpendicular axes *x*-*x* and *y*-*y*.

100

FOUR-MOTION JOINT WITH OVAL GUIDES

EM
MJ

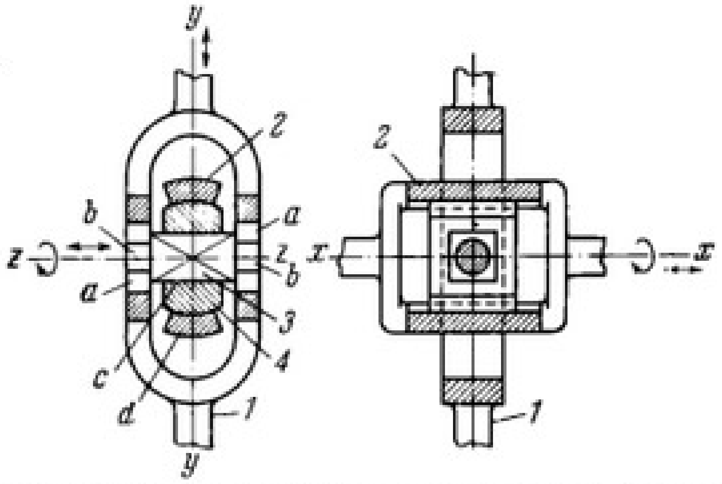


Round trunnions *b* of link *3* slide along oval guides *a* of link *1*. Square body *d* of link *3* fits into the square hole of link *4* which slides along link *3*. Link *4* also has rectangular projections which slide in guides *e* of link *2*. With respect to each other, links *1* and *2* accomplish one turning motion about axis *x-x* and three translational motions along three perpendicular axes *x-x*, *y-y* and *z-z*.

101

FIVE-MOTION JOINT WITH A BARREL-SHAPED SLIDING MEMBER

EM
MJ

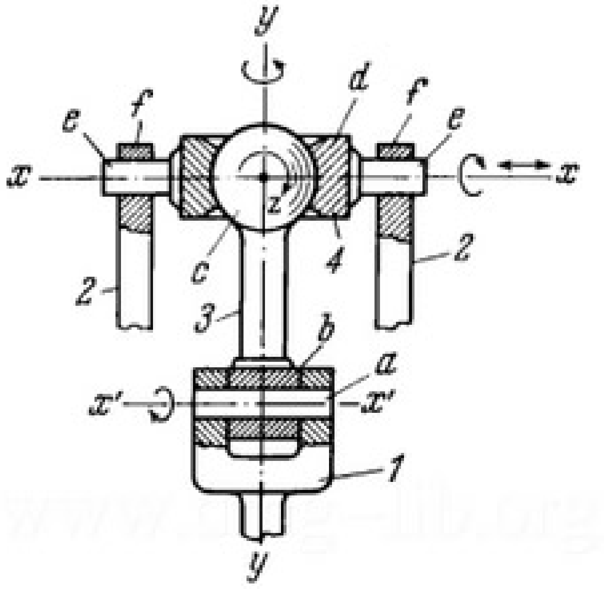


Round trunnions *b* of link *3* slide along oval guides *a* of link *1*. Barrel-shaped link *4* slides along square body *c* of link *3*. The cylindrical surface of link *4* fits into cylindrical guides *d* of link *2*. With respect to each other, links *1* and *2* accomplish two turning motions about perpendicular axes *x-x* and *z-z*, and three translational motions along perpendicular axes *x-x*, *y-y* and *z-z*.

102

FIVE-MOTION JOINT WITH A BALL-SHAPED HEAD

EM
MJ



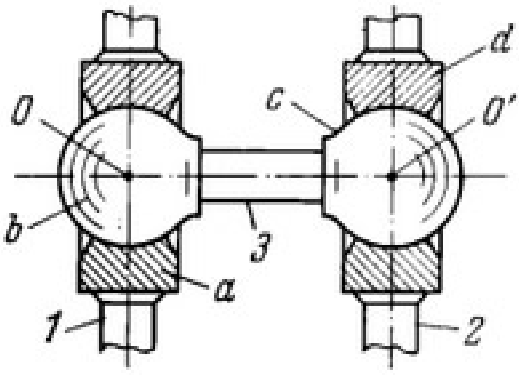
Link *1* has pin *a* fitting into a hole in end *b* of link *3*. Ball-shaped head *c*, at the other end of link *3*, fits into spherical half-collars *d* of link *4*. Round trunnions *e* of link *4* fit into the holes in prongs *f* of link *2*. With respect to each other, links *1* and *2* accomplish four turning motions about three perpendicular axes *x-x*, *y-y* and *z-z*, and about axis *x'-x'*, and one translational motion along axis *x-x*.

103

FIVE-MOTION JOINT WITH TWO BALL-SHAPED HEADS

EM

MJ



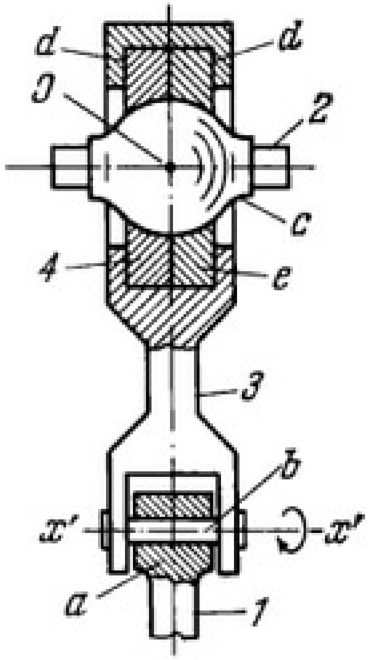
Link *1* has spherical half-collars *a* fitting over ball-shaped head *b* of link *3*. At its other end link *3* has a second ball-shaped head *c* fitting into spherical half-collars *d* of link *2*. With respect to each other, links *1* and *2* accomplish five turning motions about the three perpendicular axes intersecting at point *O* and about two perpendicular axes intersecting at point *O′*.

104

FIVE-MOTION JOINT WITH A BOX-SHAPED GUIDE

EM

MJ

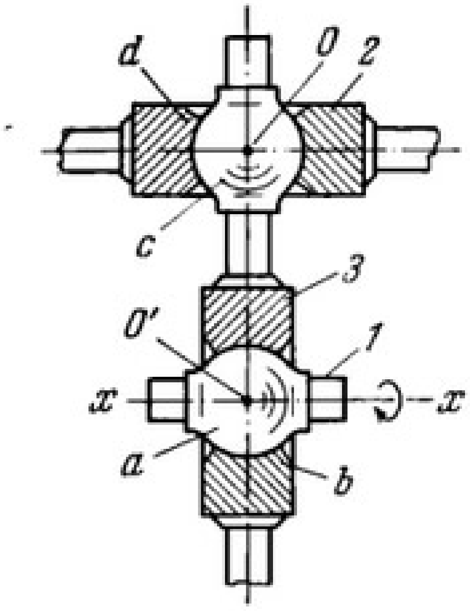


Pin *b* of link *3* fits into hole *a* of link *1*. Link *3* has, at its other end, box-shaped rectangular guide *d* along which sliding member *4* travels. Sliding member *4* has spherical half-collars *e* fitting over barrel-shaped head *c* of link *2*. With respect to each other, links *1* and *2* accomplish four turning motions about the three perpendicular axes intersecting at point *O* and about axis *x′-x′*, and one translational motion along an axis square to the plane of the drawing.

105

FIVE-MOTION JOINT WITH TWO BARREL-SHAPED HEADS

EM
MJ

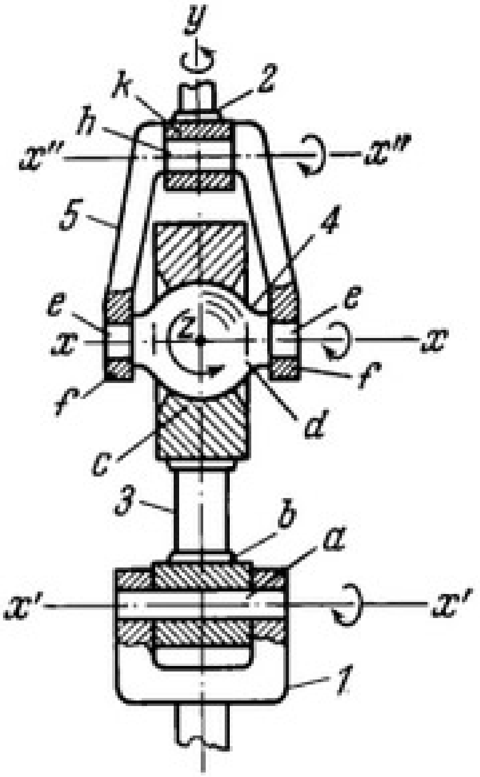


Link *1* has barrel-shaped head *a* fitting into spherical half-collars *b* of link *3*. Link *3* has barrel-shaped head *c* fitting into spherical half-collars *d* of link *2*. With respect to each other, links *1* and *2* accomplish five turning motions about the three perpendicular axes intersecting at point *O* and about two perpendicular axes intersecting at point *O′*.

106

FIVE-MOTION JOINT WITH A BALL-SHAPED HEAD

EM
MJ

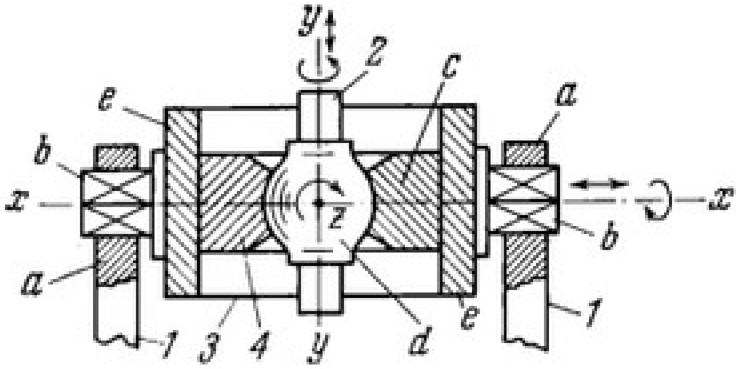


Pin *a* of link *1* fits into the hole at end *b* of link *3*. Spherical half-collars *c*, at the other end of link *3*, fits over ball-shaped head *d* of link *4*. Round trunnions *e* of link *4* fit into holes in prongs *f* of fork *5*. Pin *h* of fork *5* fits into a hole in end *k* of link *2*. With respect to each other, links *1* and *2* accomplish five turning motions about three perpendicular axes *x-x*, *y-y* and *z-z*, and about two parallel axes *x′-x′* and *x″-x″*.

107

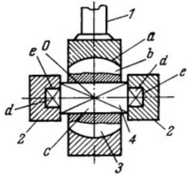
FIVE-MOTION JOINT WITH TWO SLIDING MEMBERS

EM
MJ



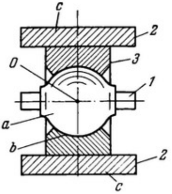
Link *1* which is one sliding member has prongs *a* with square holes which fit over square guides *b* of link *3*. Sliding member *4* travels in box-shaped guide *e* of link *3*. Sliding member *4* consists of spherical half-collars *c* which fit over ball-shaped head *d* of link *2*. With respect to each other, links *1* and *2* accomplish three turning motions about perpendicular axes *x-x*, *y-y* and *z-z*, and two translational motions along perpendicular axes *x-x* and *y-y*.

108 FIVE-MOTION JOINT WITH A BARREL-SHAPED SLIDING MEMBER EM MJ



Spherical surface *b* of barrel-shaped link *3* fits into spherical half-collars *a* of link *1*. Link *3* (sliding member) slides along square guide *c* of link *4* which has two square lugs *d* at its ends that slide along guide slots *e* of link *2*. With respect to each other, links *1* and *2* accomplish three turning motions about the three perpendicular axes intersecting at point *O*, and two translational motions along perpendicular axes in a plane square to the plane of the drawing.

109 FIVE-MOTION JOINT WITH FLAT GUIDES EM MJ

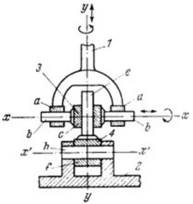


Ball-shaped head *a* of link *1* fits into spherical half-collars *b* of sliding member *3* that travels between flat guides *c* of link *2*. With respect to each other, links *1* and *2* accomplish three turning motions about the perpendicular axes intersecting at point *O*, and two translational motions along perpendicular axes lying in a plane of the flat guides.

110

FIVE-MOTION JOINT WITH TWO CYLINDRICAL GUIDES

EM
MJ

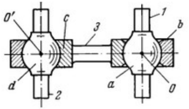


Round guides *b* of link *3* fit into holes in prongs *a* of link *1*. Round guide *e* of link *4* fits into body *c* of link *3*. Pin *h* of link *2* fits into a hole in body *f* of link *4*. With respect to each other, links *1* and *2* accomplish three turning motions about two perpendicular axes *x-x* and *y-y*, and about axis *x'-x'* (parallel to axis *x-x*), and two translational motions along axes *x-x* and *y-y*.

111

FIVE-MOTION JOINT WITH TWO BARREL-SHAPED HEADS

EM
MJ



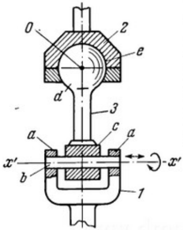
Link *1* has barrel-shaped head *a* fitting into spherical half-collars *b* of link *3*. Link *2* has barrel-shaped head *d* fitting into spherical half-collars *c* of link *3*. With respect to each other, links *1* and *2* accomplish five turning motions about the three perpendicular axes intersecting at point *O* and about two perpendicular axes intersecting at point *O'*.

112

FIVE-MOTION JOINT WITH A CYLINDRICAL GUIDE

EM

MJ



Round guide (pin) *b*, secured in prongs *a* of link *1*, fits into a hole in end *c* of link *3*. Ball-shaped head *d*, at the other end of link *3*, fits into spherical recess *e* of link *2*. With respect to each other, links *1* and *2* accomplish four turning motions about the three perpendicular axes intersecting at point *O* and about axis *x′-x′*, and one translational motion along axis *x′-x′*.

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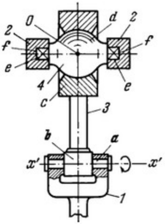
113

FIVE-MOTION JOINT WITH PRISMATIC GUIDES

EM

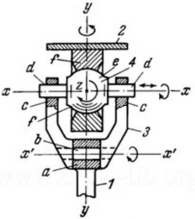
MJ



Pin *a* of link *1* fits into a hole in end *b* of link *3*. Spherical half-collars *c*, at the other end of link *3*, fit over barrel-shaped head *d* of link *4*. Square lugs *e* of link *4* slide along prismatic guides *f* of link *2*. With respect to each other, links *1* and *2* accomplish four turning motions about the three perpendicular axes intersecting at point *O* and about axis *x′-x′*, and one translational motion along an axis square to the plane of the drawing.

114

FIVE-MOTION JOINT WITH CYLINDRICAL GUIDES

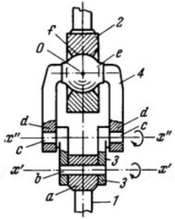


Pin *b* in link *3* fits into a hole in end *a* of link *1*. Cylindrical guides *d* of link *4* fit in holes in prongs *c* of link *3*. Barrel-shaped head *e* of link *4* fits into spherical half-collars *f* of link *2*. With respect to each other, links *1* and *2* accomplish four turning motions about three perpendicular axes *x*-*x*, *y*-*y* and *z*-*z* and about axis *x′*-*x′*, and one translational motion along axis *x*-*x*.

115

FIVE-MOTION JOINT WITH A BARREL-SHAPED HEAD

EM
MJ

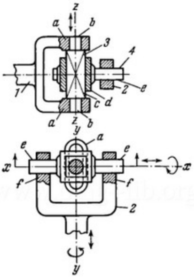


Pin *b* of link *3* fits into a hole in end *a* of link *1*. Trunnions *c* of link *3* fit into holes in prongs *d* of link *4*. Link *4* has barrel-shaped head *e* fitting into spherical half-collars *f* of link *2*. With respect to each other, links *1* and *2* accomplish five turning motions about the three perpendicular axes intersecting at point *O* and about two parallel axes x'-x' and x''-x''

116

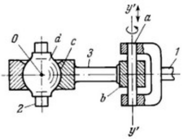
FIVE-MOTION JOINT WITH OVAL GUIDES

EM
MJ



Round trunnions *b* of link *3* rotate and slide along oval guides *a* of link *1*. Square body *c* of link *3* fits into a square hole in body *d* of link *4*. Link *4* has round trunnions *e* fitting into holes in prongs *f* of link *2*. With respect to each other, links *1* and *2* accomplish two turning motions about perpendicular axes *x-x* and *z-z*, and three translational motions along perpendicular axes *x-x*, *y-y* and *z-z*.

117 FIVE-MOTION JOINT WITH A CYLINDRICAL GUIDE EM MJ



Round guide (pin) *a*, secured in link *1*, fits into a hole in end *b* of link *3*. Spherical half-collars *c*, at the other end of link *3*, fit over barrel-shaped head *d* of link *2*. With respect to each other, links *1* and *2* accomplish four turning motions about the three perpendicular axes intersecting at point *O* and about axis *y'*-*y'*, and one translational motion along axis *y'*-*y'*.

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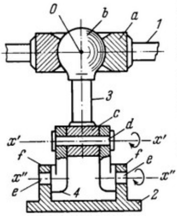
118 FIVE-MOTION JOINT WITH A BALL-SHAPED HEAD EM MJ

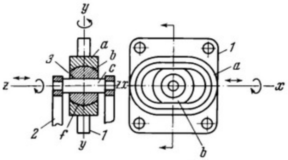


Link *1* has spherical half collars *a* that fit over ball-shaped head *b* of link *3*. Pin *d* of link *4* fits into a hole at the other end *c* of link *3*. Trunnions *e* of link *4* fit into holes in prongs *f* of link *2*. With respect to each other, links *1* and *2* accomplish five turning motions about the three perpendicular axes intersecting at point *O* and about parallel axes *x'*-*x'* and *x''*-*x''*.

119

FIVE-MOTION JOINT WITH OVAL GUIDES

EM
MJ



Barrel-shaped head *b* of link *3* fits into and slides along oval guides *a*, of round cross section, in link *1*. Round guide pin *c* of link *2* fits into a hole in the head of link *3*. With respect to each other, links *1* and *2* accomplish three turning motions about three perpendicular axes *x-x*, *y-y* and *z-z*, and two translational motions along perpendicular axes *x-x* and *z-z*.

SECTION TWO

Simple Lever Mechanisms

SL

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1. Lever Mechanisms L (120 through 162).
2. Gripping, Clamping and Expanding Mechanisms GC (163 through 245).
3. Balance Mechanisms B (246 through 251).
4. Brake Mechanisms Br (252 through 257).
5. Stop, Detent and Locking Mechanisms SD (258 through 334).
6. Switching, Engaging and Disengaging Mechanisms SE (335 through 361).
7. Indexing Mechanisms I (362 through 405).
8. Sorting and Feeding Mechanisms SF (406 through 429).
9. Governor Mechanisms G (430 through 440).
10. Clutch and Coupling Mechanisms C (441 through 459).
11. Mechanisms of Measuring and Testing Devices M (460 through 478).
12. Hammer, Press and Die Mechanisms HP (479 through 483).
13. Key Mechanisms K (484 through 487).
14. Mechanisms of Materials Handling Equipment MH (488 through 492).
15. Safety Mechanisms S (493 and 494).
16. Link-Length Adjustment Mechanisms LL (495 through 502).
17. Mechanisms for Mathematical Operations MO (503 through 506).
18. Contacting Lever Mechanisms CL (507 through 523).
19. Mechanisms of Other Functional Devices FD (524 through 538).

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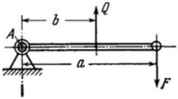
1. LEVER MECHANISMS (120 through 162)

120 SINGLE-ARM LEVER

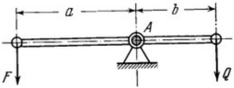
SL
L



In uniform rotation of the lever, force F equals $F = Q\frac{b}{a}$, where a and b are the lengths of perpendiculars dropped from point A to the directions of action of forces F and Q.

121 DOUBLE-ARM LEVER

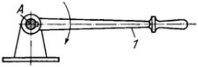
SL
L



In uniform rotation of the lever, force F equals $F = Q\frac{b}{a}$, where a and b are the lengths of perpendiculars dropped from point A to the directions of action of forces F and Q.

122 HAND LEVER

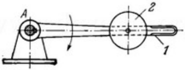
SL
L



Lever *1* turns about fixed axis *A*. Lever *1* is turned by a force applied by the hand to the handle of the lever.

123 WEIGHTED LEVER

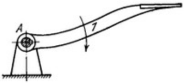
SL
L



Lever *1* turns about fixed axis *A*. Lever *1* is turned due to weight *2* fastened rigidly to it.

124 PEDAL (FOOT LEVER)

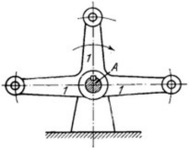
SL
L



Pedal *1* turns about fixed axis *A*. Pedal *1* is turned by depressing its step with the foot.

125 TRIPLE-ARM BELL-CRANK LEVER

SL
L



Lever *1* turns about fixed axis *A*. The lever is turned by a force applied to any of its arms.

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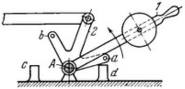
126 WEIGHTED LEVER

SL
L

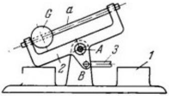


Levers *1* and *2* turn freely about fixed axis *A*. When lever *1* is turned by hand from one extreme position to the other, it actuates lever *2*, engaging pin *a* or *b*, turning it to stop *d* or *c*. The weight holds the lever in either extreme position.

127

LEVER WITH A SHIFTING WEIGHT

SL
L



Link *2* turns about fixed axis *A*. Weight *G* can slide freely along bar *a* of link *2* which is connected by turning pair *B* to driving link *3*. Link *2* is indexed in its extreme positions by the shifting of weight *G* from one end of the bar to the other. At this link *2* bears against one of the two supports of base *1*.

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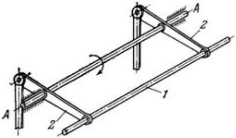
128

TWIN DOUBLE-ARM LEVER

SL
L



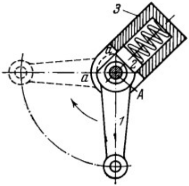
Twin double-arm lever 2 turns about fixed axis *A*. It is turned by a force applied to bar handle *1*.]

129

SPRING-INDEXED TWO-POSITION LEVER

SL

L



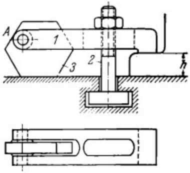
Lever *1* turns about fixed axis *A*. When lever *1* is turned to the position indicated by dash lines, it will contact spring-loaded sliding member *2* along flat *a-a*, being thereby indexed in the second position. Spring housing *3* is fixed.

130

ADJUSTABLE-HEIGHT PLAIN LEVER CLAMP

SL

L

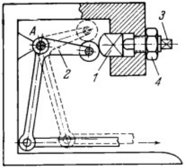


Clamp (lever) *1* turns about pin *A* in hexagon *3* and can be secured by T-bolt *2* and a nut in the position shown in the drawing. Pin *A* is located eccentrically in the hexagon. In clamping workpieces of various heights *h*, the tilt of the clamp can be reduced by setting the hexagon on the face *a* for which the tilt is minimal.

131

INDEXABLE BELL-CRANK LEVER

SL
L



Double-arm (bell-crank) lever *2* turns about fixed axis *A* and can occupy the two positions shown in the drawing. It is rigidly indexed in either of these positions by sliding-member *1* which slides in a fixed guide. The sliding member is actuated by screw *3* which can be locked in place by locknut *4*.

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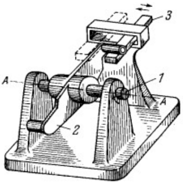
132

DOUBLE-ARM LEVER WITH INTERMITTENT ROTATION

SL
L

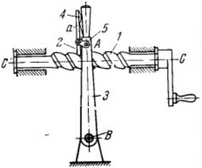


Double-arm lever *2* is mounted rigidly on shaft *1* which rotates about axis *A-A* owing to a constant torque applied to it. Upon reciprocation of pawl *3* in the directions shown by the arrows, shaft *1* rotates intermittently by half-revolutions. The time required for pawl *3* to shift from one position to the other should be slightly less than the time per half-revolution of shaft *1*.

133 WORM-DRIVE LEVER

SL

L



Lever *3* is turned about fixed axis *B* by rotating worm *1* about fixed axis *C-C*. Flat spring *4* holds latch *2* in engagement with the worm. When handle *a* of latch *2* is depressed, the latch is disengaged from the worm and lever *3* can be turned freely about axis *B*. To enable latch *2* to be freely disengaged from the worm the latch is connected to lever *3* through an intermediate link *5* that turns freely about axis *A*.

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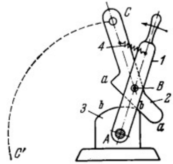
134 LEVER WITH A FIXED CAM

SL

L

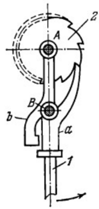


Lever *1* turns about fixed axis *A*. Link *2* is hinged to lever *1* by turning pair *B*. The straight edge *a-a* of link *2* is in contact with contour *b-b* of fixed cam *3*. When lever *1* is turned counterclockwise point *C* of link *2* travels to position *C'*. Various paths *CC'* of point *C* can be obtained by changing the contour *b-b* of cam *3*. Spring *4* holds link *2* against the cam.

135

LEVER WITH A RATCHET WHEEL

SL
L



Double-arm lever *1*, consisting of links *a* and *b* hinged together by turning pair *B*, and ratchet wheel *2* rotate about fixed axis *A*. When lever *a* is turned counterclockwise, ratchet wheel *2* is also turned. When turned in the opposite direction, lever *a* is disengaged from ratchet wheel *2* and is returned to its initial T position.

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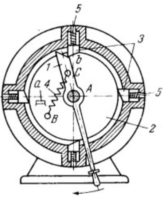
136

LEVER WITH A RATCHET WHEEL

SL
L

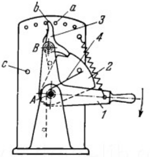


Lever *1* rotates about fixed axis *A*. Ratchet wheel *2* rotates about axis *A* independently of lever *1*. Latches *3*, actuated by springs *5*, consecutively engage ratchet wheel *2* by dropping into slot *b* of wheel *2*. One end of spring *4* is secured at point *B* of ratchet wheel *2* and the other end at point *C* of lever *1*. When lever *1* is turned clockwise, its bevelled end disengages latch *3* from wheel *2* which is indexed by spring *4* to the next position. Lug *a* limits the amount of rotation of ratchet wheel *2*.

137

LEVER WITH A RATCHET SEGMENT

SL
L·



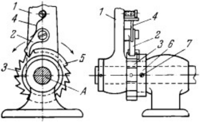
Lever *1*, turning about fixed axis *A*, has hinged pawl *3* at point *B*. Segment *2* turns about axis *A* independently of lever *1*. When lever *1* is turned clockwise, pawl *3* turns segment *2* in the same direction, tensioning flat spring *4*. Pawl *3* is disengaged from the segment when its tip *b* runs up against pin *a*. After disengagement of pawl *3*, segment *2* is turned by spring *4* in the reverse direction up to stop *c*.

138

LEVER WITH AN ADJUSTABLE-DWELL RATCHET WHEEL

SL

L

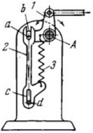


Lever *1* and ratchet wheel *3* turn independently of each other about fixed axis *A*. Lever *1* turns freely while ratchet wheel *3* is secured rigidly to the shaft. As driving lever *1* oscillates about axis *A*, pawl *2*, mounted on the lever and actuated by spring *4*, engages ratchet wheel *3*, turning it intermittently with dwells of adjustable length. Mounted on the support is collar *6* having projecting segment *5* serving as a shield for the ratchet wheel. Collar *6* can be secured by setscrew *7* in any position with respect to the ratchet wheel. Shield *5* disengages pawl *2* from ratchet wheel *3*. By setting collar *6* in various positions it is possible to adjust the length of the dwell of the ratchet wheel.

139 SELF-RESETTING LEVER

SL

L



Lever *1* turns about fixed axis *A*. Pin *a* of lever *1* slides along slot *b* of link *2*. Link *2* has slot *c* at its other end sliding along fixed pin *d*. If lever *1* is deviated in either direction from the position shown in the drawing, it is returned by spring *3* to its initial position.

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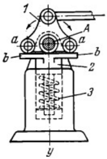
140 SELF-RESETTING LEVER

SL

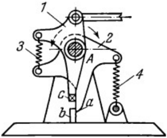
L



Lever *1* turns about fixed axis *A*. Rollers *a*, mounted on lever *1*, roll along flat surface *b* of link *2*. Link *2* travels in a straight line along axis *A-y*. If lever *1* is deviated from the position shown in the drawing, it is returned by spring *3* to its initial position.

141 SELF-RESETTING LEVER

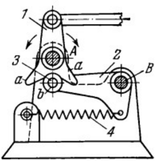
SL
L



Levers *1* and *2* turn independently of each other about fixed axis *A*. Lever *1* has lug *c* and lever *2* has lug *a*. If lever *1* is turned clockwise, lever *2* is stationary because lug *a* abuts against fixed stop *b*. If lever *1* is turned counterclockwise, lever *2* is turned by lug *c* and the two levers turn as a single link. In the free state, the levers are returned by spring *3* in the first case, and by spring *4* in the second to the position shown in the drawing.

142 SELF-RESETTING LEVER

SL
L

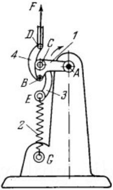


Lever *1*, turning about fixed axis *A*, has two lugs *a*. Roller *b* is mounted on the end of lever *2* which turns about fixed axis *B*. If lever *1* is turned in either direction, one of the lugs *a* depresses roller *b* and turns lever *2*. Spring *4* returns lever *2*, and, consequently, lever *1*, to the position shown in the drawing.

143

SELF-RESETTING LEVER

SL
L

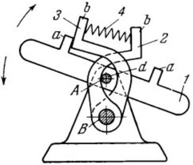


Lever *1*, turning about fixed axis *A*, is connected by turning pairs *B* and *C* to links *4* and *3*. Force *F*, applied at point *D*, turns lever *1* clockwise about axis *A*. Spring *2* returns lever *1* to the position shown in the drawing where points *D*, *C*, *B*, *E* and *G* lie on a straight line.

144

SELF-RESETTING LEVER

SL
L

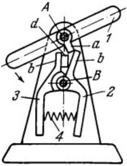


Lever *1* turns about fixed axis *A*. Levers *2* and *3* turn independently of each other about fixed axis *B*. Lever *1* has two lugs *a* and levers *2* and *3* have lugs *b*. As lever *1* is oscillated, its lugs *a* alternately engage lugs *b* of levers *2* and *3*. At this the other lever (lever *2* as illustrated) is forced by spring *4* against pin *d* mounted at axis *A*, compressing the spring. When lever *1* is released it will be returned by spring *4* and the first lever (lever *3* as illustrated) to its initial (central) position.

145 SELF-RESETTING LEVER

SL

L



Lever *1*, turning about fixed axis *A*, has lug *a*. Levers *2* and *3*, linked together by spring *4*, have projections *b*. When lever *1* is turned to either side, lug *a* engages projection *b* of lever *2* or *3* (lever *2* as illustrated). This lever is turned about fixed axis *B*, forcing projection *b* of the other lever against stop *d* and compressing spring *4*. When lever *1* is released, it is returned by spring *4* to its initial (central) position.

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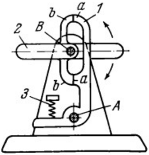
146 SELF-RESETTING LEVER

SL

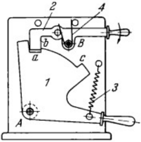
L



Lever *1*, turning about fixed axis *A*, has two projections *a*. Lever *2*, turning about fixed axis *B*, has projections *b*. When lever *2* is turned in either direction, one of its projections *b* contacts the corresponding projection *a* and causes lever *1* to turn clockwise about its axis *A*, compressing spring *3*. When lever *2* is released, it will be returned by spring *3* to its initial (central) position.

147 SELF-RESETTING LEVER

SL
L



Lever *1*, turning about fixed axis *A*, has slot *a*, and lever *2*, turning about fixed axis *B*, has corresponding projection *b*. When projection and slot are engaged, lever *1* is in the position illustrated in the drawing. In the stationary position of lever *1*, its projection *c* abuts against projection *b* of lever *2*. If lever *2* is disengaged from lever *1*, lever *1* is returned to its initial (stationary) position by spring *3*. Lever *2* is held in its engaged position with lever *1* by flat spring *4*.

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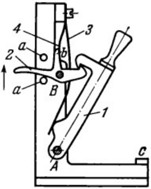
148 SELF-RESETTING LEVER

SL
L

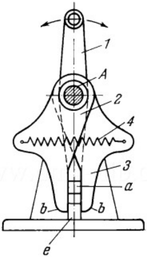


Lever *1* turns about fixed axis *A* and is subject to the action of flat spring *3*. Latch *2* can turn about fixed axis *B* through the angle limited by stops *a* and is subject to the action of flat spring *4* bearing against lug *b* of the latch. When engaged, lever *1* is in the position shown in the drawing. If latch *2* is disengaged from lever *1* the latter will be returned by spring to its initial position in which it rests on stop *c*.

149

SELF-RESETTING LEVER

SL
L



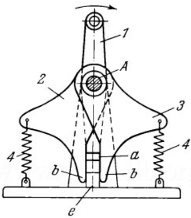
Lever *1*, turning about fixed axis *A*, has lug *a* gripped between arms *b* of levers *2* and *3*, also turning about axis *A*. Spring *4* holds arms *b* of levers *2* and *3* against fixed stop *e*. When turned in either direction, lever *1* is returned to its initial vertical position by spring *4*.

150

SELF-RESETTING LEVER

SL

L

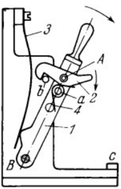


Lever *1*, turning about fixed axis *A*, has lug *a* gripped between arms *b* of levers *2* and *3*, also turning about axis *A*. Springs *4* hold arms *b* of levers *2* and *3* against fixed stop *e*. When turned in either direction, lever *1* is returned to its initial vertical position by the corresponding spring *4*.

151

SELF-RESETTING LEVER

SL
L

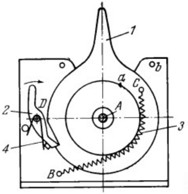


Lever *1*, turning about fixed axis *B*, is subject to the action of flat spring *3*. Latch *2* turns about axis *A* in lever *1* and is subject to the action of flat spring *4* which is bent around pin *a* of lever *1*. When engaged, lever *1* is in the position shown in the drawing. If latch *2* is disengaged from pin *b*, lever *1* will be returned by spring *3* to the initial position determined by stop *c*. Spring *4* holds latch *2* in engagement with pin *b*.

152

SELF-RESETTING LEVER

SL
L

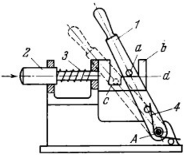


Drum *a* is rigidly secured to lever *1* which turns about fixed axis *A*. End *C* of spring *3*, running over the drum, is secured to lever *1*, end *B* is anchored to the frame. When lever *1* is turned counterclockwise, spring *3* returns it to its initial position where it is locked by latch *2* which turns about axis *D*. When latch *2* is turned clockwise, it is disengaged from lever *1* which is turned by spring *3* about axis *A* until it runs up against stop *b*. Flat spring *4* holds latch *2* against lever *1*.

153 SELF-RESETTING LEVER

SL

L

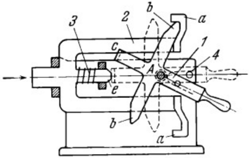


Lever *1*, turning about fixed axis *A*, has pin *a* and is subject to the action of flat spring *4*. Link *2* has slotted component *b*, of complex shape, at one end. Component *b* has two flat surfaces, *d* and *c*, arranged at different levels. When engaged, lever *1* is in the position shown in the drawing, i.e. where pin *a* rests on surface *d*. When link *2* is pushed toward the right, lever *1* is returned by spring *4* to the initial position (shown by dash lines), i.e. where pin *a* rests on surface *c*. Spring *3* returns link *2* to its initial position when lever *1* is turned clockwise.

154

SELF-RESETTING LEVER

SL
L

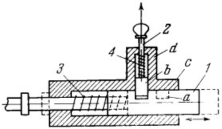


Cross-shaped lever *1* turns about fixed axis *A* and is subject to the action of flat spring *4*. Link *2* has two prongs with projections *a*. Ends *b* of the cross-shaped lever engage projections *a* which serve as latches. In an engaged condition, lever *1* is in the position shown in the drawing. When link *2* is pushed to the right, lever *1* is returned by spring *4* to its initial position (shown by dash lines). At this, end *c* of lever *1* contacts end *e* of link *2*. Lever *1* has dual action: it can also engage lower projection *a* of link *2*. Spring *3* returns link *2* to its initial position.

155

SELF-RESETTING PLUNGER

SL
L

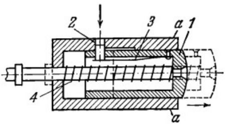


Link (plunger) *1*, having transverse slot *a*, slides along fixed guide *c*. Link *2* has head *b* at one end. Head *b* slides along guide *d* which is square to the axis of guide *c*. Helical spring *4* holds link *2* against link *1*. In the engaged condition, links *1* and *2* are as shown in the drawing. If link *2* is disengaged, link *1* is returned by spring *3* to its initial position, shown in the drawing by dash lines.

156

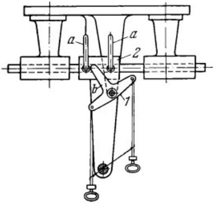
SELF-RESETTING PLUNGER

SL
L



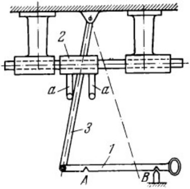
Plunger *1*, sliding along fixed guides *a*, has a round hole in which round link *2* can slide axially in a direction square to the axis of guide *a*. Link *2* is subject to the action of flat spring *3*. When engaged, plunger *1* and link (pin) *2* are in the position shown in the drawing. If link *2* is depressed through the hole in the frame, plunger *1* will be returned by spring *4* to its initial position, shown in the drawing by dash lines.

157 BELT-SHIFTING LEVER SL L



Link 2 is shifted from one extreme position to the other by the action of arm *b* of lever *1* on pins *a* of link 2. Link 2 directly actuates the belt which is not shown.

158 BELT-SHIFTING LEVER SL L

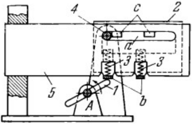


Notches *A* and *B* index handle *1* in its extreme positions. Link *2* is shifted from one position to the other by the action of lever *3* on bent pins *a* of link *2*. Link *2* directly actuates the belt which is not shown.

159

LEVER-TYPE LOCK

SL
L



Key *1* is turned about fixed axis *A*. Plate *2* has projections *c* and lugs *b*. Springs *3* are arranged between lugs *b* and bolt *5* of the lock. As the key is turned, its barb pushes upward on lug *b*, sliding plate *2* upward against the resistance of springs *3*. Projections *c* are thereby raised, releasing bolt *5* to slide forward along fixed pin *4*. This closes the lock.

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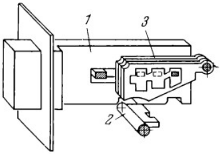
160

LEVER MECHANISM OF A DOOR LOCK

SL
L

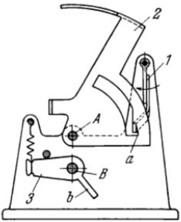


Movement of link *1*, the bolt, is possible only when the projections and grooves of the barb on key *2* conform to the contours of plates *3*. The key and its position with respect to plates *3* is shown arbitrarily.

161

LEVER MECHANISM OF A DROPPING SHUTTER

SL
L

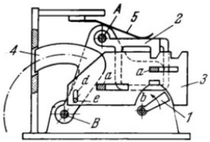


When lever *1* is turned clockwise, projection a of shutter *2* is released and the shutter turns clockwise about fixed axis A until it runs against stop link *3*. To return shutter **2** to its initial position, link *3* is turned about fixed axis B, raising the shutter with lug b to the position shown in the drawing.

162

LEVER MECHANISM OF A LOCK

SL
L

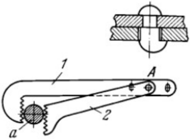


When key *1* is turned counterclockwise, link *2*, overcoming the resistance of flat spring *5* and turning about fixed axis *A*, releases link *3*. As it turns further, key *1* acts on contour *b*, pushing link *3* in a straight line along fixed pins *a*. At this, pin *e* of lever *4*, the bolt, slides along slot *d* of link *3* and lever *4* is turned counterclockwise about fixed axis *B*, thereby closing the lock.

2. GRIPPING, CLAMPING AND EXPANDING MECHANISMS (163 through 245)

163 LEVER-TYPE PIPE WRENCH

SL
GC



Hinge *A* of the wrench can be adjusted to any of three positions to suit the size of the pipe or bar *a* being gripped. To provide convenience in setting the wrench, the hinge pin is designed as a hook-shaped pivot which readily comes out of the holes in lever *1* when turned through 90°.

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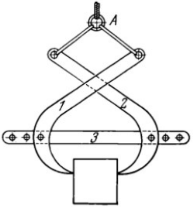
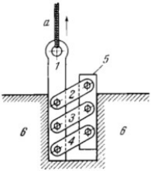
164 LEVER-TYPE LIFTING TONGS

SL
GC



The load to be lifted is gripped when ring *A* is pulled upward. The mechanism permits adjustment to the size of the load by setting the hinges of levers *1* and *2* to various positions on link *3*.

165 LEVER-TYPE SPREADING GRIP SL GC



When link *1* is pulled upward by rope *a*, the intermediate links *2*, *3*, and *4* jam link *5* in a slot of load *6* being lifted. The load is hoisted by the friction forces developed between the jammed links *1* and *5* and the slot in load *6*.

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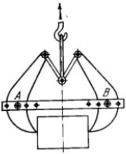
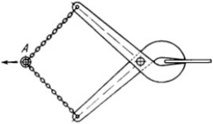
166 LEVER-TYPE LIFTING TONGS SL GC



The load to be lifted is gripped when the hook is pulled upward. Pins *A* and *B* are set to the size of the load.

167 LEVER-TYPE GRIPPING TONGS

SL
GC



A strip or sheet is gripped when ring *A* is pulled in the direction of the arrow.

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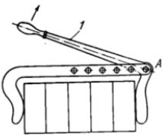
168 LEVER-TYPE GRIP FOR BRIQUETTES

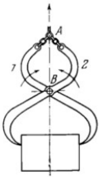
SL
GC



Briquettes are gripped by turning lever *1* clockwise about pivot *A*. The distance between the cheeks of the grip can be adjusted to suit the size and number of briquettes being handled.

169 LEVER-TYPE LIFTING TONGS

SL
GC



The load being lifted is gripped when ring *A* is pulled upward and levers *1* and *2* turn about pivot *B* in the directions shown by the arrows.

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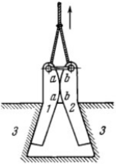
170 LEVER-TYPE GRIP

SL
GC

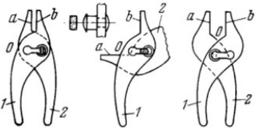


Load *3* is lifted by a tapered slot by means of levers *1* and *2* having contoured portions *a-a* and *b-b*. The contours of the portions and of the levers depend upon the shape of the slot in the load.

171 SLIP-JOINT PLIERS

SL

GC



The object is gripped between faces *a* and *b* when links (handles) *1* and *2* are squeezed together. The pliers have two size adjustments obtained by slipping the pivot (joint) as shown.

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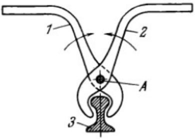
172 LEVER-TYPE RAIL-CARRYING TONGS

SL

GC

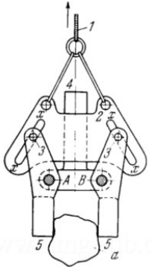


Rail *3* is gripped for carrying by turning levers (handles) *1* and *2* about fixed axis *A* in the directions shown by the arrows.

173

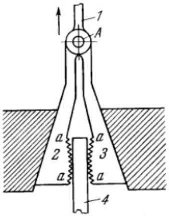
LEVER AND SLOTTED-PLATE GRIPPING MECHANISM WITH A GUIDE

SL
GC



When hoisting rope *1* is pulled upward, link *2*, having slots *x-x*, is moved upward along guiding link *4*. Pins *3* of levers *5* slide along slots *x-x* and levers *5* are turned about their fixed axes *A* and *B* until the ends of the levers grip load *a*.

174 LEVER AND WEDGE GRIP SL GC



Links *2* and *3*, turning about axis *A*, are of wedge shape with serrated surfaces *a-a*. When link *1* is pulled in the direction of the arrow, links *2* and *3* grip object *4*.

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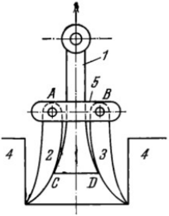
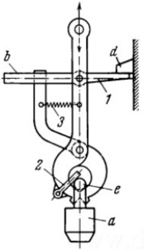
175 LEVER AND WEDGE GRIP SL GC



Links *2* and *3* turn about pivots *A* and *B* of link *5*. Points *C* and *D* slide along the contoured surfaces of links *2* and *3*. When wedge *1* is pulled in the direction of the arrow, links *2* and *3* are spread and jam in the slot of load *4* being gripped.

176 LEVER TONGS

SL
GC



When drop hammer *a* is lifted upward, tripping lever *1* runs against stop *d* and its end *b* is raised, thereby opening the tongs and allowing the hammer to drop. As the hammer drops, latch *2* drops between the tong jaws, keeping them spread. When the tongs are lowered to grip shackle *e* of drop hammer *a*, latch *2* is lifted by the shackle and spring *3* closes the tong jaws. End *b* of tripping lever *1* drops down and locks the tongs.

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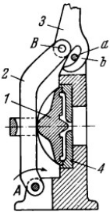
177 LEVER-TYPE CLAMP

SL
GC

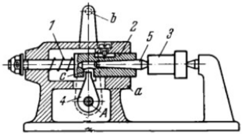


Lever *2* turns about fixed axis *A*. Link *3* is connected to lever *2* by a turning pair and ends in hook member *b* which slides along fixed pin *a* when link *3* is turned. At this lever *2* clamps workpiece *4* by means of component *1* which slides freely along lever *2*.

178

LEVER AND PLUNGER CLAMPING DEVICE FOR A CENTRE STOCK

SL
GC

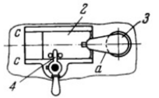


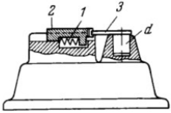
Plunger (spindle) *2* slides along fixed guide *a* of the stock and holds taper-shank centre *5*. Workpiece *3* is clamped between centres by spindle *2* due to the action of spring *1*. Lever *4* with crank handle *b* turns about fixed axis *A* and has a head *c* that enters a slot in spindle *2*. Lever *4* serves to retract spindle *2* for releasing workpiece *3*.

179

LEVER-TYPE CLAMP WITH A SLIDING MEMBER

SL
GC



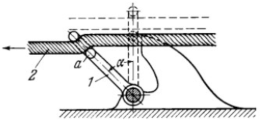


Workpiece *3* has round shank *d*, located in a hole of a stationary boss, and arm *a*. Sliding member *2* travels in fixed guides *c-c*. Workpiece *3* is located and clamped by sliding member *2* which is subject to the action of spring *1*. Lever *4* serves to retract the sliding member for removing the workpiece.

180

LEVER-TYPE ROPE CRAMP

SL
GC



Lever *1* ends in eye *a* having an internal diameter equal to the rope diameter. Rope *2* is secured by turning lever *1* from the vertical position through angle α whose magnitude depends upon the friction force between eye *a* and the rope.

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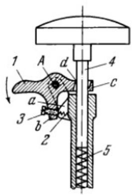
181

LEVER-TYPE CLAMP FOR A DENTIST'S CHAIR

SL
GC

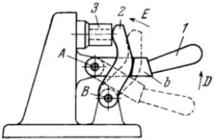


Lever *1*, turning about fixed axis *A*, has lug *b* which has screw *3* for compressing spring *2*. In arm *c* of lever *1* is slanting hole *d* through which rod *4* slides. Rod *4* is subject to the action of spring *5*. Due to the action of spring *2*, lever *1* tends to bend rod *4* and locks it in any given position. When lever *1* is turned counterclockwise about axis *A* until it runs against stop *a*, the slanted hole becomes aligned with rod *4* which is thereby released and raised by spring *5*. The force exerted by spring *2* can be adjusted by screw *3*. This adjusts the bending moment acting on rod *4*.

182

LEVER CLAMP

SL
GC



Lever *1*, turning about fixed axis *A*, has lug *b* which comes into contact with the external contour of lever (clamp) *2*, turning about fixed axis *B*. When lever *1* is turned in the direction of arrow *D*, lug *b* turns lever *2* in the direction of arrow *E*, thereby clamping workpiece *3*. The initial position of the levers is shown by dash lines.

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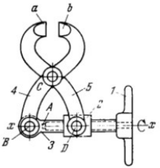
183

LEVER-TYPE HAND VISE

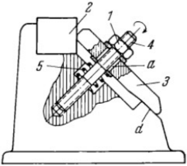
SL
GC



Link *1* is connected by a screw pair to link *2* and by turning pair *A* to link *3*. Links *4* and *5* are connected by turning pair *C*. Link *4* is connected to link *3* by turning pair *B*, and link *2* to link *5* by turning pair *D*. The workpiece is clamped by jaws *a* and *b* when link *1* is turned about axis *x-x*.

184 LEVER-TYPE SCREW-ACTUATED CLAMP

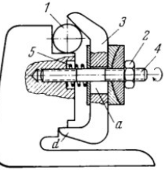
SL
GC



Nut *1* is connected by a screw pair to stud *4* which is screwed tightly into the base. Stud *4* passes through hole *a* in link (clamp) *3* with a clearance. Workpiece *2* is clamped by link *3* upon tightening nut *1*. When the nut is released, spring *5* raises clamp *3* to its initial position.

185 LEVER-TYPE SCREW-ACTUATED CLAMP

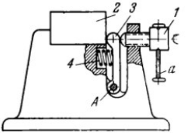
SL
GC



Nut *2* is connected by a screw pair to stud *4* whose other end is screwed tightly into the base. Stud *4* passes through slot *a* in lever (clamp) *3*. The lower end of clamp *3* ends in lug *d* which locates the clamp in the required position. Worpiece *1* is clamped by clamp *3* upon tightening nut *2*. When the nut is released, spring *5* returns clamp *3* to its initial position.

186 LEVER-TYPE SCREW-ACTUATED CLAMP

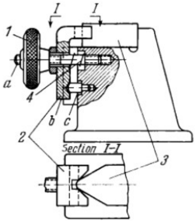
SL
GC



Link (screw) *1* is connected to the base by a screw pair and its tip bears against lever *3* which turns about fixed axis *A*. Workpiece *2* is clamped by lever *3* when screw *1* is tightened by turning it with slide-bar handle *a*.

187 LEVER-TYPE SCREW-ACTUATED CLAMP

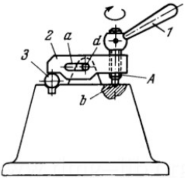
SL
GC



Nut *1* is connected by a screw pair to fixed stud *a* which passes through lever *2* with a certain clearance. Lever (clamp) *2* is supported at its lower end *b* by button *c*. Workpiece *3* is clamped by clamp *2* when nut *1* is tightened. When the nut is released, spring *4* returns clamp *2* to its initial position.

188 LEVER-TYPE SCREW-ACTUATED CLAMP

SL
GC

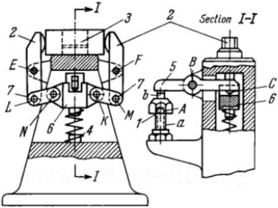


Link *1* is connected by screw pair *A* to lever (sliding clamp) *2*. Tip *b* of the screw enters a spotted seat in the base. Clamp *2* has slot *a* by means of which it slides along fixed pin *d*. Workpiece *3* is clamped by lever *2* when link *1* is turned in the direction of the arrow (screwed in).

189

LEVER-TYPE SCREW-ACTUATED EQUALIZING CLAMPING MECHANISM

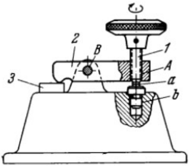
SL
GC



Nut *1* is connected by screw pair *A* to fixed bolt *a* and has a cap with tip *b* which slides along lever *5*. Lever *5* turns about fixed axis *B* and at point *C* depresses link *6* which is supported by spring *4*. Links *7* are connected to link *6* by turning pairs *N* and *K*, and to links (clamps) *2* by turning pairs *L* and *M*. Clamps *2* turn about fixed axes *E* and *F*. When nut *1* is unscrewed, lever *5* depresses link *6*. The motion of link *6* is transmitted through links *7* to clamps *2* which clamp workpiece *3*. The forces exerted by the two clamps are equalized. Spring *4* returns clamps *2* to their initial position when nut *1* is screwed on bolt *a*.

190 LEVER-TYPE SCREW-ACTUATED CLAMP

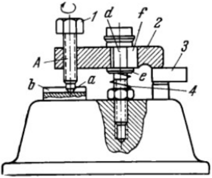
SL
GC



Link *1* is connected by screw pair *A* to lever (clamp) *2* which turns about fixed axis *B*. Tip *a* of link (screw) *1* bears against and slides along the flat head of button *b*. Workpiece *3* is clamped by lever *2* when link *1* is screwed in.

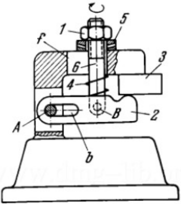
191 LEVER-TYPE SCREW-ACTUATED CLAMP

SL
GC



Link *1* is connected by scerw pair *A* to lever (sliding clamp) *2*. Tip *a* of link (screw) *1* slides along slot *b* of the base. Bolt *d* passes freely through slot *f* in clamp *2*. The clamp is supported by spring *4* through washer *e*. Workpiece *3* is clamped by lever *2* when link *1* is screwed in. Spring *4* returns lever *2* to its initial position.

LEVER-TYPE SCREW-ACTUATED CLAMP

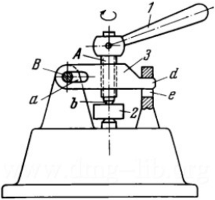


Nut *1* is connected by a screw pair to eye-bolt *6* which is connected by turning pair *B* with lever (clamp) *2*. Lever *2* has slot *b* by means of which it slides along fixed pin *A*. Eye-bolt *6* slides freely along slot *f* of the fixed link (base). Spherical washer *5* fits loosely on eye-bolt *6*. Workpiece *3* is clamped by lever *2* when nut *1* is tightened. Spring *4* returns lever *2* to its initial position.

193

LEVER-TYPE SCREW CLAMP

SL
GC



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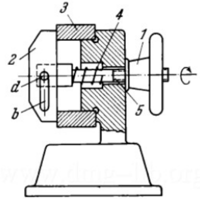
Link *1* is connected by screw pair *A* to lever *3* which has slot *a* sliding along fixed pin *B*. Lug *d* of lever *3* freely enters slot *e* of the fixed link (base). Workpiece *2* is clamped by tip *b* of link *1* when the latter is screwed into lever *3*. Slot *a* enables lever *3* to be shifted along the slot and to be turned to the side together with link *1* when the latter is released.

194

LEVER-TYPE SCREW-ACTUATED CLAMP

SL
GC



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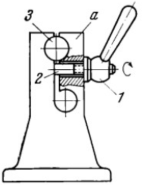
Nut *1* is connected to bolt *5* by a screw pair. At its other end bolt *5* has pin ***d*** which enters slot ***b*** of strap clamp *2*. Workpiece *3* is clamped by strap clamp *2* when nut *1* is tightened. Spring *4* returns strap clamp *2* to its initial position when nut *1* is released. To remove the ring-shaped workpiece, strap clamp *2* is pulled upward along slot ***b*** and turned about pin ***d***.

195

LEVER-TYPE SCREW-ACTUATED CLAMP

SL
GC

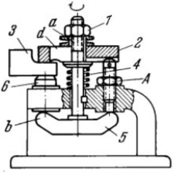


Link *1* is connected by a screw pair to stud *2* which is screwed tightly into the fixed link (base). Workpiece *3* is clamped by springy part *a* of the base when link (nut) *1* is tightened.

196

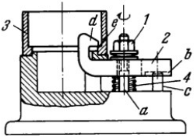
LEVER-TYPE SCREW-ACTUATED EQUALIZING CLAMP

SL
GC



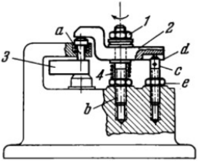
Nut *1* is connected by a screw pair to bolt *a* of link *5* whose end *b* bears against component (sliding rest button) *6*. Lever (sliding clamp) *2* has slot *d* by means of which it can slide along bolt *a*. Workpiece *3* is clamped by an equalized force between lever *2* and component *6* when nut *1* is tightened. Spring *4* serves to return lever *2* to its upper position. Lever *2* can be pulled back along slot *d* to remove the workpiece. The device is adjusted by means of screw pair *A*.

197 LEVER-TYPE SCREW-ACTUATED CLAMP SL GC



Nut *1* is connected by a screw pair to stud *a* which is screwed tightly into the fixed link (base). Lever (shaped clamp) *2* is mounted freely on stud *a* and has slot *b* that slides along on pin *c*. Considerable clearance is provided between bolt *a* and lever *2*. Lever (clamp) *2* has hooked end *d* which clamps shoulder *e* of workpiece *3*. Workpiece *3* is clamped by lever *2* when nut *1* is tightened. When nut *1* is released, spring *4* raises lever *2* which can be pushed forward to enable workpiece *3* to be removed.

198 LEVER-TYPE SCREW-ACTUATED CLAMP SL GC

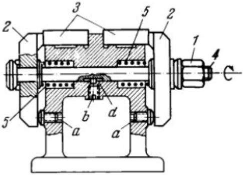


Nut *1* is connected by a screw pair to stud *b* which is screwed tightly into the fixed link (base). Lever (clamp) *2* is mounted freely on stud *b* and has slot *d* that slides along screw support *c* which is screwed tightly into the base. Workpiece *3* is clamped through pin *a* by lever *2* when nut *1* is tightened. Spring *4* raises lever *2* to its initial position when nut *1* is released. The device is adjusted by screw support *c* and locknut *e*.

199

LEVER-TYPE SCREW-ACTUATED CLAMP

SL
GC

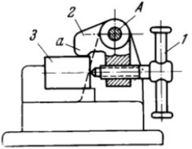


Nut *1* is connected by a screw pair to bolt *4* on which are mounted levers (clamps) *2*. The clamps bear with one end against workpieces *3* and with the other end against buttons *a*. Bolt *4* has slot *d* by means of which it slides along the tip of setscrew *b*. Two workpieces *3* are clamped by levers *2* when nut *1* is tightened. Springs *5* retract levers *2* to their initial position when nut *1* is released.

200

LEVER-TYPE SCREW-ACTUATED CLAMP

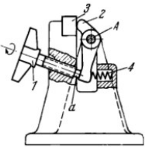
SL
GC



Link *1* is connected by a screw pair to lever (clamp) *2* which turns about fixed axis *A*. Lever *2*, bearing with its end *a* against workpiece *3*, clamps the workpiece when link *1* is turned (screwed in).

201 LEVER-TYPE SCREW-ACTUATED CLAMP

SL
GC



Link *1* is connected by a screw pair to the fixed link (base) and its tip *a* bears against two-arm lever *2* which turns about fixed axis *A*. Workpiece *3* is clamped by lever *2* when link *1* is turned (screwed in). Spring *4* retracts lever *2* to its initial position when link *1* is released.

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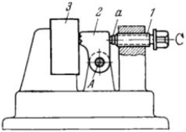
202 LEVER-TYPE SCREW-ACTUATED CLAMP

SL
GC

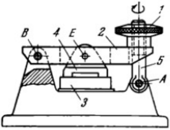


Link *1* is connected by a screw pair to the fixed link (base) and its tip *a* bears against lever (clamp) *2* which turns about fixed axis *A*. Workpiece *3* is clamped by lever *2* when link *1* is turned (screwed in).

203 LEVER-TYPE SCREW-ACTUATED CLAMP

SL

GC

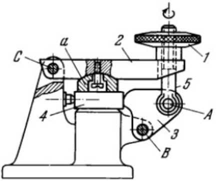


Link *1* is connected by a screw pair to link *5* which turns about fixed axis *A*. Lever *2* turns about fixed axis *B*. Link *5* passes with considerable clearance through a slot in the end of lever *2*. Link (swivel pad) *4* is connected by turning pair *E* to lever *2*. Workpiece *3* is clamped by link *4* when link *1* is turned (screwed on).

204 LEVER-TYPE SCREW-ACTUATED CLAMP

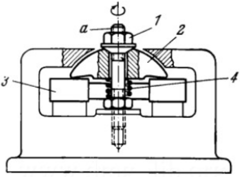
SL

GC



Link *1* is connected by a screw pair to link *5* which is connected by turning pair *A* to link *3*. Link *3* turns about fixed axis *B*. Lever *2* turns about fixed axis *C*. Link *5* passes with considerable clearance through a slot in the end of lever *2*. Workpiece *4* is clamped by levers *2* and *3* when link *1* is turned (screwed on). Lever *2* has self-aligning pad *a* for uniformly clamping the workpiece.

205 LEVER-TYPE SCREW-ACTUATED CLAMP SL GC

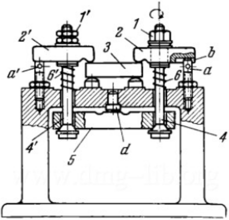


Nut *1* is connected by a screw pair to stud *a* which is screwed tightly into the fixed link (base). Stud *a* passes with clearance through a hole in segment *2*. Workpiece *3* is clamped by segment *2* when nut *1* is tightened. Spring *4* raises segment *2* when nut *1* is released.

206

LEVER-TYPE SCREW-ACTUATED CLAMP

SL
GC



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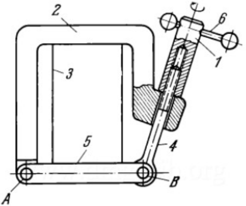
Nut *1* is connected by a screw pair to bolt *4*. Bolt *4* passes with clearance through an elongated hole in lever *2*. Lever *2* slides with its slot *b* along screw support *a* which is screwed tightly into the fixed link (base). The symmetrical arrangement consists of nuts *1'*, lever *2'* and bolt *4'*. Bolts *4* and *4'* pass through holes in link *5* which bears against button *d*. The device is adjusted by nuts *1'*, one serving as a locknut. Workpiece *3* is clamped by levers *2* and *2'* when nut *1* is tightened. Screw supports *a* and *a'* serve to adjust the device so that levers *2* and *2'* are approximately horizontal in the clamped position. Springs *6* and *6'* raise levers *2* and *2'* to their initial position when nut *1* is released.

207

LEVER-TYPE SCREW-ACTUATED CLAMP

SL

GC

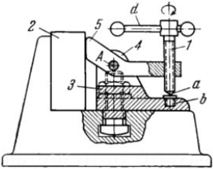


Link *1* is connected by a screw pair to link *4*. Link *5* is connected by turning pairs *A* and *B* to links *2* and *4*. Link *4* passes with considerable clearance through a hole in link *2*. Workpiece *3* is clamped by links *2* and *5* when link *1* is turned (screwed on).

208

LEVER-TYPE SCREW-ACTUATED CLAMP

SL
GC

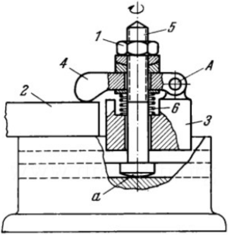


Link *1* is connected by a screw pair to lever *5* which turns about pin *A* of bracket *4*. Tip *a* of link *1* bears against the head of button *b*. Workpiece *2* is clamped by lever *5* when link *1* is turned (screwed in) by means of bar handle *d*.

209

LEVER-TYPE SCREW-ACTUATED CLAMP

SL
GC



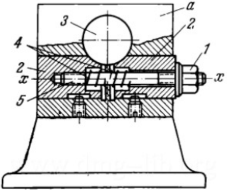
Nut *1* is connected by a screw pair to bolt *5* whose head *a* is inserted in a T-slot of the base. Bolt *5* passes with clearance through holes in supporting member *3* and lever *4* which turns about pin *A* of member *3*. Workpiece *2* is clamped by lever *4* when nut *1* is tightened. Supporting member *3* can be adjusted along the T-slot to enable workpieces of various width to be clamped. Spring *6* raises lever *4* to its initial position when nut *1* is released.

210

SCREW-ACTUATED CLAMP FOR ROUND WORKPIECES

SL

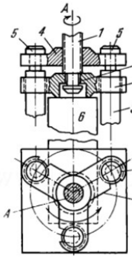
GC



Stud *5* passes freely through the hole in right-hand shoe *2* and is screwed tightly into left-hand shoe *2*. When nut *1* is tightened, shoes *2* clamp round workpiece *3*, forcing it upward into upper part *a* of the base member. Springs *4* serve to spread shoes *2*, returning them to their initial position, when nut *1* is released.

211 SCREW-ACTUATED CLAMP

SL
GC



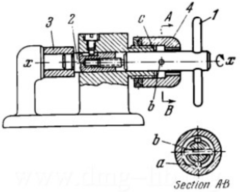
Link *1* is connected by a screw pair to three-armed member *4* and passes freely through hole *a* in clamp *2*. Workpiece *6* is clamped against a stationary surface (not shown in the drawing) by clamp *2*, sliding along cylindrical columns *3* when member *1* is turned (screwed in). Three-armed member *4* is held by heads *5* of columns *3* and can be quickly removed by turning it counterclockwise about screw *1* (fixed axis *A*).

212

SCREW-ACTUATED CLAMP WITH A RETRACTING DEVICE

SL

GC



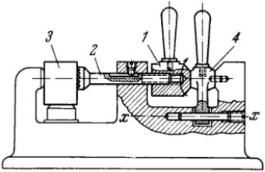
Link *1* is connected by a screw pair to member *2* which slides in a hole in the base. Link *1* has pin *b* enclosed by cover nut *4* which is screwed onto a connection of the base. The nut has slots *a* through which pin *b* can pass along axis *x-x*. To clamp workpiece *3*, link *1* is first pushed into nut *4*, pin *b* passing through slots *a*, and then turned (screwed out). To release the workpiece, link *1* is first turned (screwed in) and then pulled out of nut *4*. The position of clamping member *2* is adjusted by nut *4* and its round locknut.

213

SCREW-ACTUATED CLAMP WITH A SWINGING SUPPORT

SL

GC



Upon turning (screwing off) nut *1*, screw *2* clamps workpiece *3*. To retract the screw rapidly nut *1* is first released (screwed on) and then swinging support *4* is swung away about axis *x-x*.

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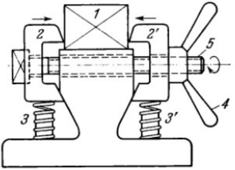
214

SCREW-ACTUATED CLAMP

SL

GC



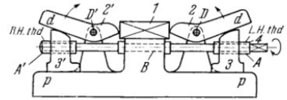
Workpiece *1* is clamped by links *2* and *2′* which are brought together when nut *4* is tightened on bolt *5*. As they are brought together, links *2* and *2′* slide downward with their bevelled surfaces along the guiding surfaces of the base, compressing springs *3* and *3′*, and pulling workpiece *1* down firmly against its locating surface. Springs *3* and *3′* raise links *2* and *2′* to their initial position when nut *4* is released.

215

SCREW-ACTUATED CAM-TYPE CLAMP

SL

GC



Links *3* and *3'* slide along stationary guide surface *p-p* and are connected by screw pairs *A* and *A'* to link *4* which, in turn, is connected by turning pair *B* to the fixed base. Lever cams *2* and *2'* turn about fixed axes *D* and *D'* and, with their straight portion *d*, contact the profiled ends of links *3* and *3'*. Workpiece *1* is clamped by lever cams *2* and *2'* which are turned by the action of cam links *3* and *3'*, having L.H. and R.H. threads and travelling towards each other when link *4* is turned clockwise.

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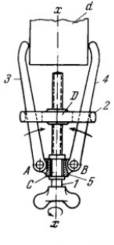
216

LEVER-TYPE SCREW-ACTUATED SELF-CENTERING CLAMP

SL

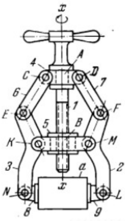
GC



Link *1* turns about axis *x-x* and is connected by turning pair *C* to link *5* and by screw pair *D* to link *2*. Links *3* and *4* are connected by turning pairs *A* and *B* to link *5* and pass with considerable clearance through holes in link *2*. Workpiece *d* is clamped by links *3* and *4* when link *1* is turned (screwed out).

217 LEVER-TYPE SCREW-ACTUATED CLAMP

SL
GC



Link *1* turns about axis *x-x* and is connected by turning pair *A* to link *4* and by screw pair *B* to link *5*. Links *6* and *7* are connected by turning pairs *C*, *D*, *E* and *F* to link *4* and to links *2* and *3*. Links *3* and *2* are connected by turning pairs *K* and *M* with link *5* and have swivel jaws *8* and *9* which are pivoted at points *N* and *L*. Workpiece *a* is clamped by jaws *8* and *9* when link *1* is turned (screwed in).

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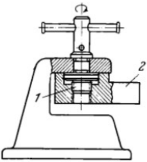
218 SCREW CLAMP

SL
GC

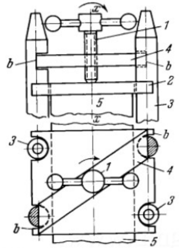


Workpiece *2* is pulled up against the locating surface when screw *1* is turned (screwed in).

219

SCREW CLAMP

SL
GC

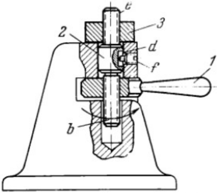


Workpiece *5* is clamped by member *2* when screw *1* is turned about axis *x-x* (screwed in). Member *2* slides along cylindrical columns *3* which serve as guides. Strap member *4* fits into slots *b* of two columns and serves as the nut for screw *1*. The workpiece can be quickly removed by first releasing screw *1* and then turning member *4* counterclockwise.

220

SCREW CLAMP

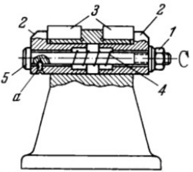
SL
GC



Link *1* is connected by a screw pair to end *b* of stud *2*. With its slot *d*, stud *2* slides along the tip of setscrew *f* which is screwed into the base. Workpiece *3* is first screwed on end *e* of stud *2* which then pulls the workpiece against the locating surface when the lever of link *1* is turned (screwed on).

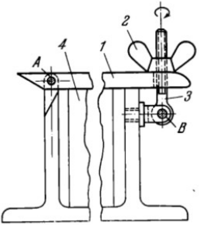
221 SCREW-ACTUATED CLAMP

SL
GC



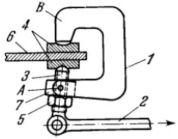
Members *2* slide along a fixed guide. Bolt *5* passes freely through the hole in right-hand member *2* and is connected to the left-hand member by means of setscrew *a*. When nut *1* is turned (screwed on), members *2* are brought together, compressing spring *4* and clamping workpieces *3*. Spring *4* returns members *2* to their initial position when nut *1* is released.

222 LEVER-TYPE SCREW-ACTUATED CLAMP SL GC



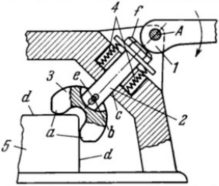
Link *1*, turning about fixed axis *A*, has a slot at its other end through which bolt *3* passes with some clearance. Bolt *3* turns about fixed axis *B*. Wing nut *2* is connected by a screw pair to bolt *3*. Workpiece *4* is clamped between link *1* and the base by tightening wing nut *2*.

223 LEVER-TYPE SCREW-ACTUATED CLAMP SL GC



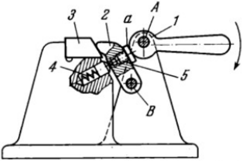
Lug *B* of C-clamp *1* bears against upper pad *4*. Screw *3* is connected by a screw pair to member *7* which turns freely about pin *A* in C-clamp *1*. The tip of screw *3* bears against lower pad *4*. Pads *4* clamp plate *6* when link *2* is pulled in the direction of the arrow. The position of screw *3* is adjusted in member *7* and then locked by nut *5*.

224 LEVER-TYPE ECCENTRIC-CAM CLAMP SL GC



The handle with circular eccentric cam *1* turns about fixed axis *A*. Eccentric cam *1* slides along head *f* of link *2*. Link *2* slides in fixed guide *c*. C-member *3* has pin *b* sliding along slot *e* in link *2*. Lugs *a* of C-member *3* act on sides *d* of workpiece *5*. When eccentric cam *1* is turned clockwise, pressure is transmitted through link *2* to C-member *3* which clamps workpiece *5*. Springs *4* release workpiece *5* when eccentric cam *1* is turned in the opposite direction.

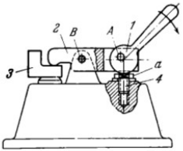
225 LEVER-TYPE ECCENTRIC-CAM CLAMP SL GC



Lever *2* turns about fixed axis *B*. The handle with circular eccentric cam *1* turns about fixed axis *A* and the cam slides along head *a* of screw *5*. Workpiece *3* is clamped by lever *2* when handle *1* is turned clockwise. Spring *4* returns lever *2* to its initial position when eccentric cam *1* is released. The clamp is adjusted by screw *5*.

226 LEVER-TYPE ECCENTRIC-CAM CLAMP

SL
GC



Lever *2* turns about fixed axis *B*. The handle with circular eccentric cam *1* turns about pin *A* and slides along head *a* of screw *4*. Workpiece *3* is clamped by lever *2* when handle *1* is turned clockwise. The clamp is adjusted by screw *4*.

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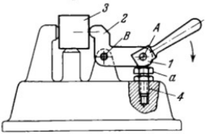
227 LEVER-TYPE ECCENTRIC-CAM CLAMP

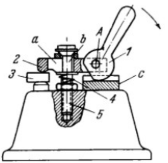
SL
GC



Lever *2* turns about fixed axis *B*. The handle with eccentric cam *1* turns about pin *A* and slides along head *a* of screw *4*. Workpiece *3* is clamped by lever *2* when handle *1* is turned clockwise. The clamp is adjusted by screw *4*.

228 LEVER-TYPE ECCENTRIC-CAM CLAMP

SL
GC



Lever *2* has slot *a* which slides along upper part *b* of screw *5*. The lever with eccentric cam *1* turns about pin *A* and slides along fixed guide *c*. Workpiece *3* is clamped by lever *2* when handle *1* is turned clockwise. Spring *4* raises lever *2* to its initial position when the eccentric cam is released. The clamp is adjusted by screw *5*.

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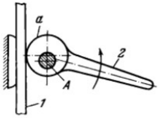
229 LEVER-TYPE ECCENTRIC-CAM CLAMP

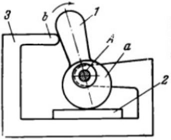
SL
GC



Lever *2*, turning about fixed axis *A*, has circular eccentric cam *a* at one end. Workpiece *1* is clamped when lever *2* is turned counterclockwise.

230 LEVER-TYPE ECCENTRIC-CAM CLAMP

SL
GC



Lever *1*, turning about fixed axis *A*, has eccentric cam *a* at one end. The cam clamps workpiece *2* against base *3*. Lug *b* serves as a stop for lever *1*.

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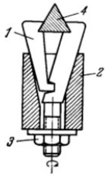
231 WEDGE-TYPE CLAMP

SL
GC

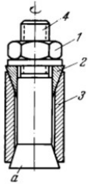


Split round wedge *1* is inserted in tapered sleeve *2*. When nut *3* is tightened, the parts of wedge *1* clamp workpiece *4*.

232 WEDGE-TYPE SCREW-ACTUATED CLAMP

SL

GC



Bolt *4* has tapered head *a*. Slotted spring sleeve *3* is expanded by tightening nut *1*. This forces tapered bushing *2* and head *a* into the tapered holes at the ends of sleeve *3*.

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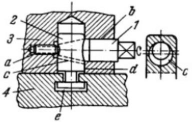
233 WEDGE-TYPE SCREW-ACTUATED CLAMP

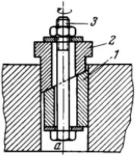
SL

GC



Link *1*, turning in fixed guide *b* of part *3*, has a threaded shank *a*. The tapered portion of link *1* fits into a corresponding tapered hole of link *2* which slides along fixed guide *d* of part *3*. There is certain clearance *c* between the tapered elements of links *1* and *2*. When link *1* is turned (screwing it into part *3*), link *2* is moved upward and its T-shaped shank *e* clamps part *4* to part *3*.

234 WEDGE-TYPE CLAMP SL GC



Bushings *1* and *2* are mounted with considerable clearance on bolt *3* and have bevelled end faces with equal angles. Bushings *1* and *2* are clamped in hole *a*, when the nut is tightened on bolt *3*, as a result of the sliding of their bevelled end faces on each other.

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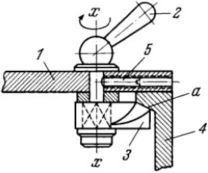
235 LEVER-WEDGE-TYPE CLAMP SL GC

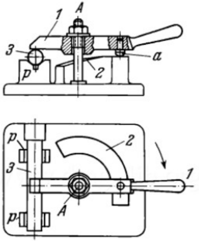


Cylindrical cam *3* is rigidly linked to handle *2* which turns about fixed vertical axis *x-x*. Cover *1* is locked to housing *4* by turning handle *2*. At this cylindrical cam *3* bears against bevelled face *a* of housing *4*, locking cover *1*. Setscrew *5* serves to fix the clamp in the closed position.

236

LEVER-WEDGE-TYPE CLAMP

SL
GC

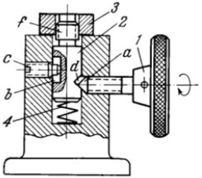


Lever *1* turns about and can slide along fixed stud *A*. When lever *1* is turned clockwise button *a* slides along wedged surface *2* and lever *1* clamps workpiece *3* mounted in V-blocks *p*.

237

WEDGE-TYPE SCREW CLAMP

SL
GC

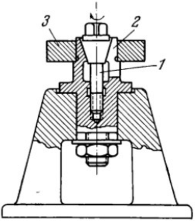


Link *1*, connected by a screw pair to the base, has conical tip *a* which enters V-shaped groove *d* in plunger *2*. Plunger *2* slides vertically in a hole in the base, its slot *b* being guided by the tip of setscrew *c* in the base. Workpiece *3* is screwed on threaded shank *f* of plunger *2*. When link *1* is turned (screwed in), plunger *2* draws workpiece *3* down tight against the locating surface. Spring *4* raises plunger *2* to its initial position when link *1* is released.

238

WEDGE-TYPE SCREW-ACTUATED CLAMP

SL
GC

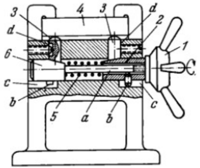


When screw *1* is turned (screwed in), slotted spring bushing *2* expands and clamps workpiece *3*.

239

WEDGE-TYPE SCREW-ACTUATED CLAMP

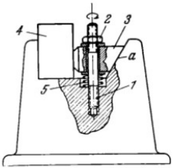
SL
GC



Link *1* is connected by a screw pair to shank *a* of wedge *6*. Shank *a* passes freely through a hole in wedge *2*. Wedges *2* and *6* are guided by pins *b* which slide along slots *c* in the fixed base. Wedges *2* and *6* slide along the bevelled ends of plungers *3* which are guided by setscrews sliding along slots *d* in the plungers. When link *1* is turned (screwed on), wedges *2* and *6* force plungers *3* upward, clamping workpiece *4*. Spring *5* returns right-hand wedge *2* and left-hand wedge *6* with its shank *a* to their initial positions when link *1* is released.

240 WEDGE-TYPE SCREW-ACTUATED CLAMP

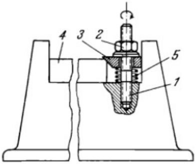
SL
GC



Nut *2* is connected by a screw pair to stud *1* which is screwed tightly into the base. Stud *1* passes through the hole in wedge *3* with a certain clearance. Bevelled end *a* of wedge *3* slides along the fixed base. Workpiece *4* is clamped by wedge *3* when nut *2* is tightened. Spring *5* raises wedge *3* to its initial position when nut *2* is released.

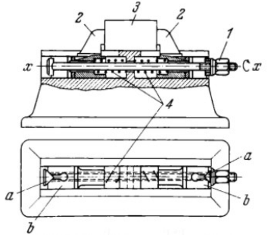
241 WEDGE-TYPE SCREW-ACTUATED CLAMP

SL
GC



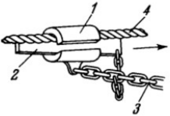
Nut *2* is connected by a screw pair to stud *1* which is screwed tightly into the base. Stud *1* passes with a certain clearance through the hole in wedge *3*. Workpiece *4* is clamped by wedge *3* when nut *2* is tightened. Spring *5* raises wedge *3* to its initial position when nut *2* is released.

242 SCREW VISE WITH LOCKING JAWS SL GC



When nut *1* is turned (tightened) about fixed axis *x-x*, vise jaws *2* clamp workpiece *3*. As nut *1* is tightened further, wedges *a* expand slotted spring bushings *b*, locking the vise jaws with respect to their guide. Springs *4* return the jaws to their initial position when nut *1* is released.

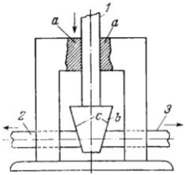
243 WEDGE-TYPE ROPE CRAMP SL GC



If chain *3* is pulled in the direction of the arrow and the tension in the chain is maintained, rope *4* is clamped (bound) between wedge *2* and sleeve *1*.

244 WEDGE-TYPE SPREADING DEVICE

SL
GC



Link *1* travels with straight-line translational motion in fixed guides *a-a* and has wedge *b* at one end. Sides *c* of wedge *b* slide along the bevelled ends of links *2* and *3* which slide in fixed guides. When link *1* is pushed downward, links *2* and *3* are spread.

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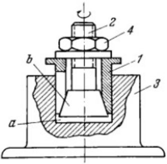
245 SCREW WITH AN EXPANDING TAPER

SL
GC

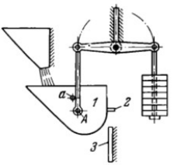


Slotted spring bushing *1* is inserted into hole *a* of base *3*. Screw *2* has tapered head *b* which expands bushing *1* when nut *4* is tightened, thereby locking the bushing in hole *a*.

3. BALANCE MECHANISMS (246 through 251)

246 BEAM BALANCE FOR LIQUIDS

SL
B



Vessel *1*, turning freely about pin *A*, is held in the working position by stop *a*. When filled a preset amount, vessel *1* descends and pin *2* runs up against stop *3* to turn over and empty the vessel.

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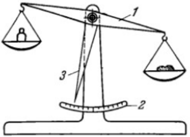
247 PAN-TYPE BEAM BALANCE

SL
B

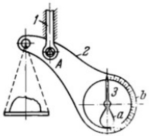


Weighing is done by means of weights placed on one pan of the balance. Beam *1* is rigidly linked to pointer *3*, and graduated scale *2* to the base.

248 UNEQUAL-ARM BEAM BALANCE

SL

B



When the item being weighed is placed on the balance pan, link (beam) *2* turns counterclockwise about pivot *A* until an equilibrium position is reached. Weight *a* holds pointer *3* in the vertical position so that it turns with respect to link *2* indicating the weight of the item on circular scale *b*. Link *1* is suspended from an upright or is held in the hand.

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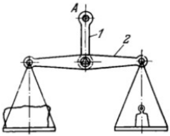
249 EQUAL-ARM BEAM BALANCE

SL

B

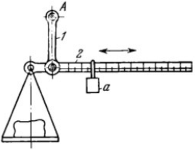


Beam *2* has a pointer and link *1* a graduated scale which are not shown in the drawing. Link *1* is suspended from an upright by means of pin *A* or is held in the hand.

250

UNEQUAL-ARM BEAM BALANCE (STEELYARD)

SL
B



Weight *a* is constant. Weighing is done by moving the weight along graduated beam *2*. Beam *2* is connected by a kinematic turning pair, in the form of a triangular prism, to link *1*. Link *1* is suspended from an upright by means of pin *A* or is held in the hand.

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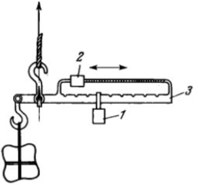
251

STEELYARD WITH TWO ADJUSTABLE WEIGHTS

SL
B

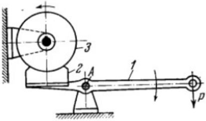


The load is weighed by means of weights *1* and *2*. Beam *3* has two graduated scales which enable more precise weighing to be performed.

4. BRAKE MECHANISMS (252 through 257)

252 LEVER-TYPE BLOCK BRAKE

SL
Br



When lever *1* is turned clockwise about fixed axis *A*, block *2* is pressed against the rim of wheel *3*, braking the wheel.

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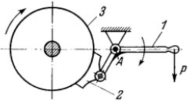
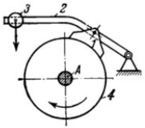
253 LEVER-TYPE BLOCK BRAKE

SL
Br



Shoe *2* is pressed against wheel *3*, applying the brake, by turning crank lever *1* about fixed axis *A*.

254 WEIGHTED-LEVER BLOCK BRAKE SL Br



Lever *2* turns about a fixed axis. Shoe *1* is pressed against wheel *4*, turning about fixed axis *A*, by loading lever *2* with weight *3*. Weight *3* is adjusted along lever *2* and secured in the required position.

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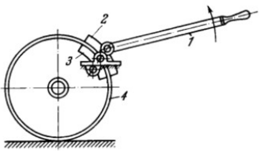
255 LEVER-TYPE DOUBLE-BLOCK BRAKE SL Br



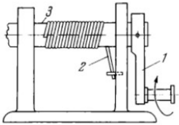
When lever *1* is turned counterclockwise, shoes *2* and *3* are brought together, clamping the rim of wheel *4*.

256

LEVER-TYPE COIL BRAKE

SL

Br



Coil spring *2* fits tightly on shaft *3* and one end bears against a stop. Crank handle *1* can be freely turned in the direction that tends to unwind the spring (here clockwise) but is braked when turned in the opposite direction.

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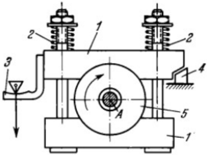
257

LEVER-TYPE BRAKE DYNAMOMETER

SL

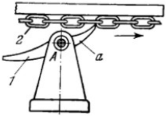
Br



Shoes *1* are pressed by springs *2* against pulley *5* which rotates about fixed axis *A*. Beam *3* is loaded until the upper shoe begins to move away from stop *4*.

5. STOP, DETENT AND LOCKING MECHANISMS (258 through 334)

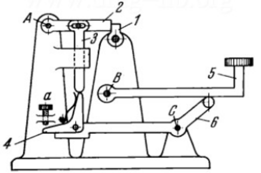
258	**LEVER-TYPE CHAIN STOP**	SL SD



Chain *2* is stopped in the required position by lever *1*. The centre of gravity of lever *1* is to the left of its turning axis *A*. Chain movement is impossible in the direction opposite to the arrow because claw *a* of lever *1* locks the chain.

259	**LEVER-TYPE KEY-OPERATED STOP**	SL SD

www.tmg-lib.org

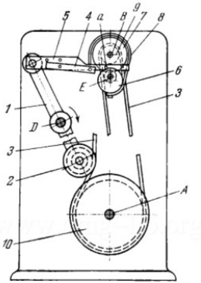


Links *2*, *5* and *6* turn about fixed axes *A*, *B* and *C*. Lever *1*, subject to a constant torque, is restrained from rotation by pawl *2* which is hinged to link *3* bearing against one arm of angle lever *4*. When key *5* is depressed by a sharp blow, lever *6* raises link *3* and disengages pawl *2* from lever *1*. As the left end of lever *6* is raised, the horizontal arm of angle lever *4* runs against adjustable stop *a*. As a result, link *3* is free to descend and permit pawl 2 to re-engage lever *1*. For further rotation of lever *1* it is necessary to return key *5* to its upper position and to depress it again. Pawl *2* is engaged either by the action of the weight of link *3* or by means of a supplementary spring.

260

LEVER-TYPE QUICK-STOP MECHANISM FOR A BELT DRIVE

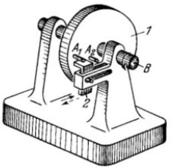
SL
SD



Rotation is transmitted by belt *3* between pulleys *9* and *10* which rotate about fixed axes *B* and *A*. Brake-drum *7* is rigidly secured to pulley *9*. One end of brake-band *8* is attached to link *5* and the other end to circular eccentric *6* which turns about fixed axis *E*. Brake-band *8* encircles brake-drum *7* and eccentric *6*. To brake and stop pulley *9*, lever *1* is turned clockwise about fixed axis *D*. This withdraws idler pulley *2* from belt *3* and advances lever *5* on which pawl *4* is attached. Pawl *4* pushes against pin *a* in eccentric *6* and turns it, thereby tightening brake-band *8* on brake-drum *7* to quickly stop pulley *9*.

261 DISK WITH INTERMITTENT ROTATION

SL
SD



Disk *1*, subject to a constant torque and turning about fixed axis *B*, carries two pins A_1 and A_2. Upon reciprocating motion of stop-dog *2* in the directions of the arrows, disk *1* makes one revolution to each motion of the stop-dog. The half-period of stop-dog reciprocation should be somewhat less than the time required for one revolution of the disk.

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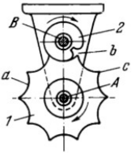
262 INTERMITTENT MOTION WITH DISK-TYPE STOP

SL
SD

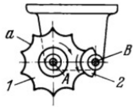


Link *1*, rotating about fixed axis *A*, has arc-shaped recesses *a* with a radius of curvature equal to the radius of disk *2* which rotates about fixed axis *B*. Link *1* is locked against rotation when disk *2* enters a recess *a*. Tooth space *b* in disk *2* allows projections *c* of link *1* to pass under disk *2* and link *1* to turn through one recess.

263

SEGMENT-TYPE STOP

SL
SD

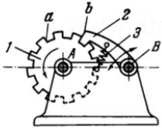


Link *1*, rotating about fixed axis *A*, has arc-shaped recesses *a* with a radius of curvature equal to the radius of segment *2* which rotates about fixed axis *B*. Link *1* is locked against rotation when segment *2* enters a recess *a*.

264

LEVER-TYPE STOP

SL
SD

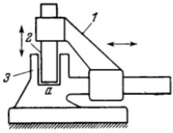


Link *1*, rotating about fixed axis *A*, has slots *a* on its circumference. Pawl *2* with tooth *b* turns about fixed axis *B* and is acted on by spring *3*. Link *1* is locked against rotation when tooth *b* enters a slot *a*.

265

PLUNGER-TYPE STOP

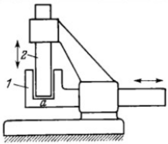
SL
SD



Link *1* is locked against translational motion when prismatic plunger *2* enters slot *a* of link *3*.

266 PLUNGER-TYPE STOP

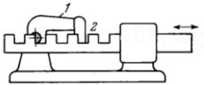
SL
SD



Link *1* is locked against translational motion when prismatic plunger *2* enters slot *a* in link *1*.

267 LEVER-TYPE STOP

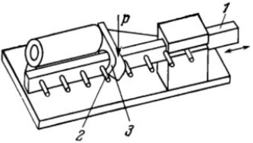
SL
SD



Rack *2* is locked against translational motion when the tooth of lever *1* enters one of its slots. Clearance between the tooth and slot enables the tooth to enter the slot.

268 LEVER-TYPE FORCE-ENGAGED STOP

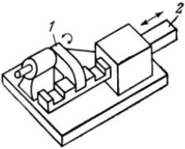
SL
SD



Force *P* holds lever *3* against pins *2* of rack *1*, locking the rack against translational motion in either direction.

269 LEVER-TYPE STOP

SL
SD



Rack *2* is locked against translational motion when lever *1* enters one of its slots.

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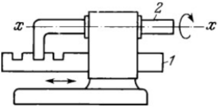
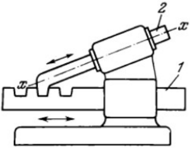
270 LEVER-TYPE STOP

SL
SD



Rack *1* is locked against translational motion when lever *2* enters one of its slots. The links are engaged by turning lever *2* about longitudinal axis *x-x*.

271 **LEVER-TYPE STOP** SL SD



Rack *1* is locked against translational motion when lever *2* enters one of its slots. The links are engaged by turning lever *2* about longitudinal axis *x-x*.

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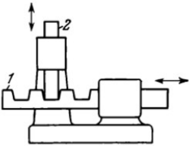
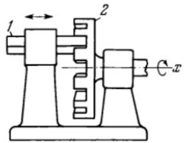
272 **PLUNGER-TYPE STOP** SL SD



Rack *1* is locked against translational motion when prismatic plunger *2* enters one of its slots.

273 PLUNGER-TYPE STOP

SL
SD



Disk *2* is locked against rotation when prismatic plunger *1* enters a slot of the disk.

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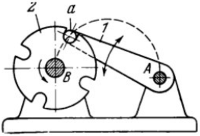
274 LEVER-TYPE STOP

SL
SD

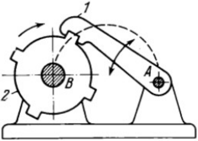


Disk *2* is locked against rotation when pin *a* of lever *1* enters a slot of the disk.

275

LEVER-TYPE STOP

SL
SD



Disk *2* rotates about fixed axis *B*; lever *1* turns about fixed axis *A*. Disk *2* is locked against rotation when one of its teeth enters the slot of lever *1*.

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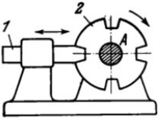
276

PLUNGER-TYPE STOP

SL
SD

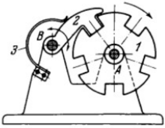


Disk *2* rotates about fixed axis *A* and plunger *1* moves horizontally. Disk *2* is locked against rotation when plunger *1* enters a slot of the disk.

277

LEVER-TYPE STOP

SL
SD



Disk *1* rotates about fixed axis *A*, lever *2* turns about fixed axis *B*. Disk *1* is locked against rotation when the tooth of lever *2* enters a slot of the disk. Spring *3* holds lever *2* in engagement with disk *1*. Lateral clearances between the tooth and slots should be sufficient to permit engagement of lever *2* when disk *1* is in rotation.

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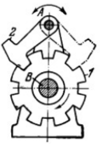
278

LEVER-TYPE STOP WITH A REVERSIBLE PAWL

SL
SD

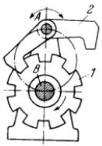


Disk *1* rotates about fixed axis *B*; pawl *2* turns about fixed axis *A*. Pawl *2* is double-ended and can be swung about axis *A* to the position shown by the dot-and-dash lines. Disk *1* is locked against rotation in either direction when a tooth of pawl *2* enters a slot of the disk.

279

LEVER-TYPE STOP WITH A TWO-ARMED PAWL

SL
SD



Disk *1* rotates about fixed axis *B*; two-armed pawl *2* oscillates about fixed axis *A*. Disk *1* is locked against rotation in either direction when a tooth of pawl *2* enters a slot of the disk.

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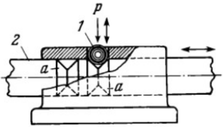
280

FORCE-ENGAGED BALL STOP

SL
SD

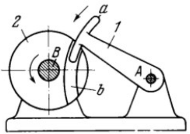


Ball *1* is held by force *P* against link *2* which has annular grooves *a*, thereby locking link *2* against translational motion in either direction.

281

LEVER-TYPE STOP OF A ROTATING DISK

SL
SD

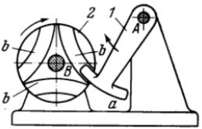


Lever *1* and disk *2* rotate about fixed axes *A* and *B*. Disk *2* is locked against rotation when circular head *a* of lever *1* enters circular slot *b* of disk *2*.

282

LEVER-TYPE STOP OF A ROTATING DISK

SL
SD

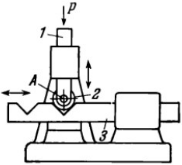


Lever *1* and disk *2* rotate about fixed axes *A* and *B*. Disk *2* is locked against rotation when circular head *a* of lever *1* enters a circular slot *b* of disk *2*.

283

FORCE-ENGAGED ROLLER STOP

SL
SD



Roller *2* of plunger *1* turns about axis *A* and is held by force *P* against rack *3* which has V-type slots, thereby locking the rack against translational motion in either direction.

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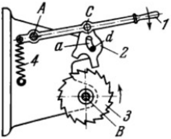
284

LEVER-TYPE STOP

SL
SD



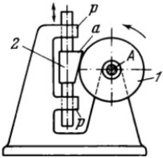
Lever *1* turns about fixed axis *A*. Ratchet wheel *3* is rotated by an independent drive about fixed axis *B*. Link *2* is connected by turning pair *C* to lever *1* and its slot *a* slides along fixed pin *d*. When lever *1* is turned clockwise, link *2* stops ratchet wheel *3*. Spring *4* returns lever *1* to its initial position when it is released.

285

WEDGE-TYPE STOP OF A ROTATING DISK

SL

SD



Disk *1* rotates about fixed axis *A*. Link *2* with wedge *a* slides in fixed guides *p-p* and stops disk *1* in its counterclockwise rotation.

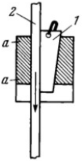
www.dmg-lib.org

286

WEDGE-TYPE STOP FOR A ROD IN TRANSLATIONAL MOTION

SL

SD



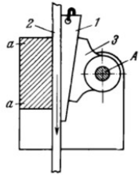
Rod *2* slides along fixed guide *a-a*. Wedge *1* locks rod *2* when it begins to move downward.

287

WEDGE-TYPE STOP FOR A ROD IN TRANSLATIONAL MOTION

SL

SD



Rod *2* slides along fixed guide *a-a*. Shoe *3* turns about fixed axis *A*. When rod *2* begins to move downward it is locked by wedge *1* whose bevelled side bears against freely turning shoe *3*.

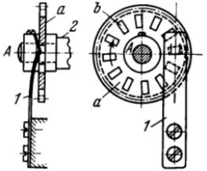
www.drag-lib.org

288

SPRING-TYPE STOP FOR A SHAFT

SL

SD



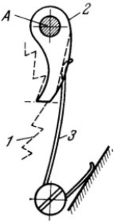
Disk *a* with slots *b*, mounted and fixed on shaft *2*, rotates about fixed axis *A* and is stopped in definite positions by flat spring *1* with a bent end.

289

RATCHET-TYPE STOP WITH A FLEXIBLE LINK

L

SD



Ratchet wheel *1* is locked against counterclockwise rotation by pawl *2* which turns about fixed axis *A*. Spring *3* holds pawl *2* in engagement with ratchet wheel *1*.

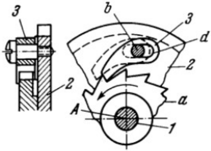
www.dmg-lib.org

290

RATCHET-TYPE STOP FOR A SHAFT

SL

SD

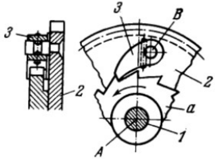


Ratchet wheel *a* is secured rigidly on shaft *1*. Link *2*, rotating freely about fixed axis *A* of shaft *1*, carries pawl *3* which turns about pin *b* and slides along this pin with slot *d*. With respect to link *2*, shaft *1* can rotate only counterclockwise; when it starts to rotate clockwise, it is locked by pawl *3*. Pawl *3* can be disengaged from ratchet wheel *a* by sliding its slot *d* along pin *b*.

291

RATCHET-TYPE STOP FOR A SHAFT

SL
SD



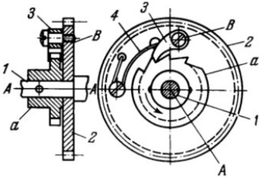
Ratchet wheel *a* is secured rigidly on shaft *1*. Link *2*, rotating freely about fixed axis *A* of shaft *1*, carries pawl *3* which turns about axis *B*. With respect to link *2*, shaft *1* can rotate only counterclockwise; when it starts to rotate clockwise, it is locked by pawl *3*.

www.mng-lib.org

292

RATCHET-TYPE STOP FOR A SHAFT

SL
SD

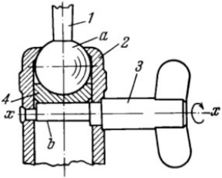


Ratchet wheel *a* is secured rigidly on shaft *1*. Link *2*, rotating freely about fixed axis *A* of shaft *1*, carries pawl *3* which turns about axis *B* and is loaded by spring *4*. With respect to link *2*, shaft *1* can rotate only counterclockwise, when it starts to rotate clockwise, it is locked by pawl *3*.

293

ECCENTRIC LOCK FOR A BALL JOINT

SL
SD

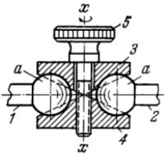


Link *1* ends in ball-shaped head *a* and is part of a ball joint with link *2*. Link *3* has the eccentric journal *b* which, when link *3* is turned about axis *x-x*, presses shoe *4* against head *a*, thereby locking link *1*.

294

SCREW-TYPE LOCK OF A DOUBLE BALL JOINT

SL
SD

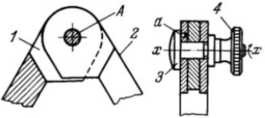


Links *1* and *2* end in ball-shaped heads *a* and are parts of a double ball joint with links *3* and *4* which have spherical recesses into which heads *a* fit. The ball joint is locked in any position of links *1* and *2* when screw *5* is turned (tightened) about axis *x-x*.

295

SCREW-TYPE LOCK OF A HINGE JOINT

SL
SD



Links *1* and *2* turn about fixed axis *A* with respect to each other. Screw *3* has pin *a* which fixes the screw head with respect to link *1*. The hinge joint is locked in any position of links *1* and *2* when thumb nut *4* is turned (tightened) about axis *A*.

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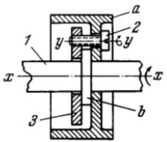
296

SCREW-TYPE STOP FOR A SHAFT

SL
SD

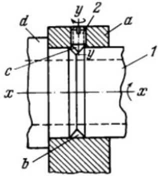


In its rotation in bearing *a* about axis *x*-*x*, shaft *1* can be locked by turning (tightening) screw *2*, whose end is screwed into washer *3*, about axis *y*-*y*. Shaft *1* has shoulder *b* which is clamped between washer *3* and the body of bearing *a*.

297 SCREW-TYPE STOP FOR A SHAFT

SL

SD



In its rotation in bearing *a* about axis *x-x*, shaft *1* can be locked by turning (tightening) setscrew *2* about axis *y-y*. Cone point *c* of setscrew *2* bears against the right-hand side of annular V-groove *b*. Shoulder *d* and setscrew *2* locate the shaft axially.

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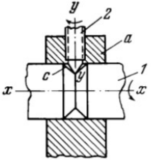
298 SCREW-TYPE STOP FOR A SHAFT

SL

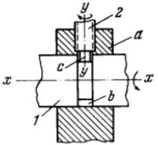
SD



In its rotation in bearing *a* about axis *x-x*, shaft *1* is locked by turning (tightening) setscrew *2* about axis *y-y*. The cone point of setscrew *2* bears against the centre of annular V-groove *c*. Setscrew *2* locates the shaft axially.

299 SCREW-TYPE STOP FOR A SHAFT

SL
SD



In its rotation in bearing *a* about axis *x-x*, shaft *1* is locked by turning (tightening) setscrew *2* about axis *y-y*. Dog point *c* of setscrew *2* bears against the bottom of annular rectangular groove *b*.

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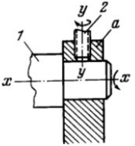
300 SCREW-TYPE STOP FOR A SHAFT

SL
SD



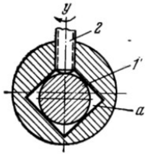
In its rotation in bearing *a* about axis *x-x*, shaft *1* is locked by turning (tightening) setscrew *2* about axis *y-y*.

301

SCREW-TYPE STOP FOR A CYLINDRICAL PLUNGER

SL

SD



Cylindrical plunger *1* is locked against axial translational motion in square guide *a* when setscrew *2* is turned (tightened) about axis *y*.

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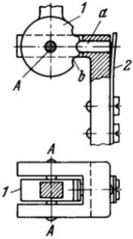
302

PIN-TYPE STOP OF A LEVER

SL

SD

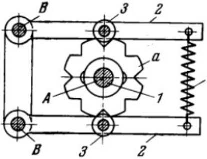


Lever *1*, turning about fixed axis *A*, is locked against rotation by pin *a* entering one of grooves *b* on the lever. Pin *a* is actuated by spring *2*.

303

ROLLER-TYPE STOP OF A SHAFT

SL
SD

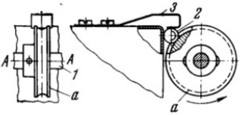


Grooved disk *a* rotates together with shaft *1*, to which it is rigidly fixed, about fixed axis *A*. Levers *2* carry rollers *3*. The levers are linked together by spring *4* and turn about fixed axes *B*. Shaft *1* is locked against rotation when rollers *3* enter the grooves of disk *a*.

304

BALL-TYPE STOP FOR A SHAFT

SL
SD

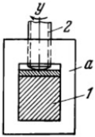


Grooved pulley *a* rotates together with shaft *1*, to which it is rigidly fixed, about fixed axis *A*. Ball *2* enters the annular groove in pulley *a* and is held there by spring *3*. Shaft *1* is locked by ball *2* when it begins to rotate counterclockwise.

305

SCREW-TYPE STOP FOR A PRISMATIC SLIDING MEMBER

SL
SD

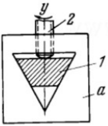


Prismatic (rectangular) sliding member (plunger) *1* is locked against axial translational motion, perpendicular to the plane of the drawing, in guide *a* when setscrew *2* is turned (tightened) about axis *y*.

306

SCREW-TYPE STOP FOR A PRISMATIC SLIDING MEMBER

SL
SD

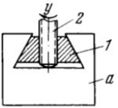


Prismatic (dovetail) sliding member (plunger) *1* is locked against axial translational motion, perpendicular to the plane of the drawing, in guide *a* when setscrew *2* is turned (tightened) about axis *y*.

307

SCREW-TYPE STOP FOR A PRISMATIC SLIDING MEMBER

SL
SD

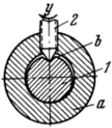


Prismatic (dovetail) sliding member (plunger) *1* is locked against axial translational motion, perpendicular to the plane of the drawing, in guide *a* when setscrew *2* is turned (tightened) about axis *y*. The flat point of setscrew *2* bears against guide *a*.

308

SCREW-TYPE STOP FOR A CYLINDRICAL SLIDING MEMBER

SL
SD



Cylindrical sliding member (plunger) *1* is locked against axial translational motion, perpendicular to the plane of the drawing, in guide *a* when setscrew *2* is turned (tightened) about axis *y*. Longitudinal V-groove *b* on plunger *1* serves as a seat for the cone point of setscrew *2*.

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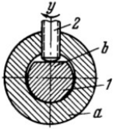
309

SCREW-TYPE STOP FOR A CYLINDRICAL SLIDING MEMBER

SL
SD



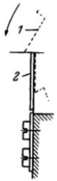
Cylindrical sliding member (plunger) *1* is locked against axial translational motion, perpendicular to the plane of the drawing, in guide *a* when setscrew *2* is turned (tightened) about axis *y*. Plunger *1* has flat *b* along its length to serve as a seat for the point of setscrew *2*.

310

SPRING-TYPE STOP FOR A RATCHET WHEEL

SL

SD



Ratchet wheel *1* is locked by flat spring *2* against counterclockwise rotation.

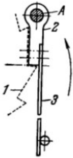
www.dmg-lib.org

311

RATCHET-TYPE STOP WITH AN ELASTIC LINK

SL

SD



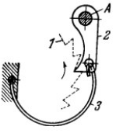
Ratchet wheel *1* is locked against counterclockwise rotation by pawl *2* which turns about fixed axis *A*. Flat spring *3* holds pawl *2* in engagement with ratchet wheel *1* and permits clockwise rotation.

312

RATCHET-TYPE STOP WITH AN ELASTIC LINK

SL

SD



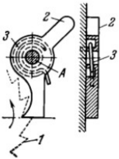
Ratchet wheel *1* is locked against counterclockwise rotation by pawl *2* which turns about fixed axis *A*. Arc-shaped spring *3* holds pawl *2* in engagement with ratchet wheel *1* and permits clockwise rotation.

313

RATCHET-TYPE STOP WITH AN ELASTIC LINK

SL

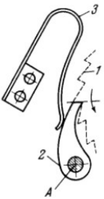
SD



Ratchet wheel *1* is locked against counterclockwise rotation by pawl *2* which turns about fixed axis *A*. Spiral spring *3* holds pawl *2* in engagement with ratchet wheel *1* and permits clockwise rotation.

314 RATCHET-TYPE STOP WITH AN ELASTIC LINK

SL
SD

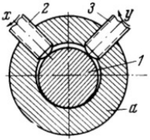


Ratchet wheel *1* is locked against counterclockwise rotation by pawl *2* which turns about fixed axis *A*. Flat spring *3* holds pawl *2* in engagement with ratchet wheel *1* and permits clockwise rotation.

www.dmg-lib.org

315 DOUBLE SCREW-TYPE STOP FOR A CYLINDRICAL SLIDING MEMBER

SL
SD

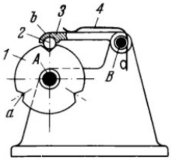


Cylindrical sliding member (plunger) *1* is locked against axial translational motion, perpendicular to the plane of the drawing, in guide *a* when setscrews *2* and *3* are turned (tightened) about axes *x* and *y*.

316

BALL-CLICK STOP

SL
SD



Disk *1*, rotating about fixed axis *A*, has V-shaped slots *a*. Ball *2* is held in spherical socket *b* of lever *3* which turns about fixed axis *B*. Lever *3* is actuated by flat spring *4*. Disk *1* is stopped when ball *2* enters one of the slots *a* in disk *1*.

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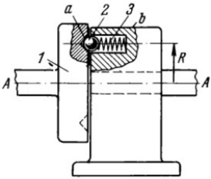
317

BALL-CLICK STOP

SL
SD

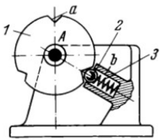


Disk *1*, rotating about fixed axis *A*, has conical recesses (spots) *a* arranged about a circle of radius *R*. Ball *2*, sliding in fixed guide (hole) *b* and actuated by spring *3*, stops disk *1* when it enters one of the recesses *a* in disk *1*.

318 BALL-CLICK STOP

SL

SD



Disk *1*, rotating about fixed axis *A*, has V-shaped slots *a*. Ball *2*, sliding in fixed guide (hole) *b* and actuated by spring *3*, stops disk *1* when it enters one of the slots *a* in disk *1*.

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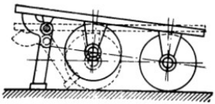
319 LOCKING LEVER FOR A WHEELED TRUCK

SL

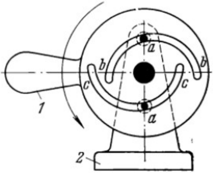
SD



In the locked condition of the truck, the lever is in the position shown in the drawing. Dashed lines show the truck and lever in the unlocked condition.

320 LEVER-TYPE LOCKING DEVICE

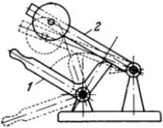
SL
SD



When lever *1* is turned counterclockwise, pins *a* are jammed in slots *b-b* and *c-c* and the device is locked. Jamming is achieved by designing slots of the proper shape.

321 WEIGHTED LOCKING LEVER

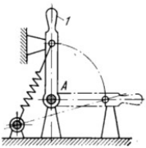
SL
SD



In the locked condition, levers *1* and *2* are in the position shown in the drawing. The unlocked position is shown by dash lines.

322 SPRING-LOADED LOCKING LEVER

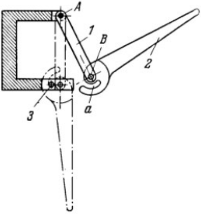
SL
SD



Lever *1* is locked by turning it about fixed axis *A* to the position shown by dot-and-dash lines.

323 LEVER-TYPE LOCK FOR A HINGED COVER

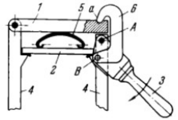
SL
SD



Cover *1*, turning about fixed axis *A*, is connected by turning pair *B* to lever *2* which has curvilinear slot *a*. Cover *1* is locked in the position shown by dot-and-dash lines by fixed pin *3* which enters slot *a* when lever *2* is turned clockwise.

324 LEVER-TYPE LOCK FOR A DOUBLE COVER

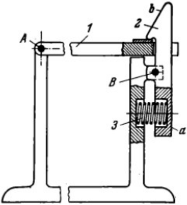
SL
SD



Lever *3*, turning about fixed axis *A*, is connected by turning pair *B* to hook *6*. This hook is swung onto upper cover *1* so that lug *a* of the hook enters a recess of cover *1*. Flat spring *5* is arranged between covers *1* and *2*. The double cover, comprising covers *1* and *2*, is locked by turning lever *3* clockwise about axis *A*. Spring *5* ensures tight fitting of cover *2* to the shoulders on walls *4*.

325 LEVER AND SPRING LATCH

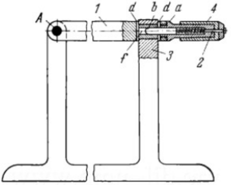
SL
SD



Cover *1* turns about fixed axis *A*. Latch *2*, turning about fixed axis *B*, has shank *a*. Spring *3* is arranged between shank *a* of latch *2* and the base. In closing, cover *1* slides along bevel *b* of latch *2*, compressing spring *3*. When the cover is closed, latch *2* snaps to the locked position by the action of spring *3*.

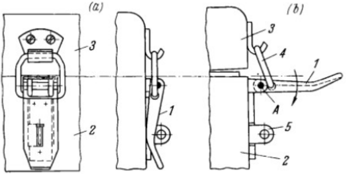
326 LEVER AND SPRING LATCH

SL
SD



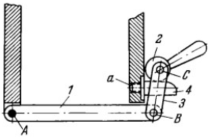
Cover *1*, turning about fixed axis *A*, has head *a*. Sliding on head *a* and along its axis is thimble *4* which is secured to rod *2* that ends in latch *b*. Cover *1* has slot *d* into which a projection of wall *3* enters. Latch *b* fits into hole *f* in the projection of wall *3*. Cover *1* is closed by retracting thimble *4* with latch *b*. When the cover is closed, thimble *4* is released and latch *b*, by the action of a spring, enters hole *f*.

327 LEVER-TYPE TRUNK LOCK SL SD



Lever *1* turns about fixed axis *A*. The parts of the lock are shown in the closed position in Fig. *a*; in Fig. *b* they are shown in the position before being completely locked. When lever *1* (Fig. *b*) is turned clockwise about axis *A*, trunk *2* is closed by cover *3* which is linked to lever *1* by a hook and heavy wire link *4*. To keep the lock in the closed position, a padlock can be put through staple *5* and locked.

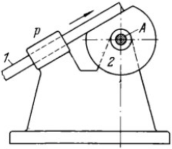
328 LEVER-TYPE ECCENTRIC-CAM LOCK FOR A HINGED BOTTOM SL SD



Hinged bottom *1* turns about fixed axis *A*. Link *3* is connected by turning pairs *B* and *C* to hinged bottom *1* and eccentric cam *2*. The lever with eccentric cam *2* turns about pin *C*. Cam *2* slides along contoured member *4* and locks the hinged bottom when the lever is turned counterclockwise. The lock is adjusted by screw *a*.

329 INTERLOCKING DEVICE

SL
SD



Disk *2* has a segment cut off and rotates about fixed axis *A*. Link *1* slides in fixed guide *p*. Disk *2* is locked against rotation by advancing link *1* into contact with the flat on the disk.

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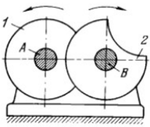
330 INTERLOCKING DEVICE

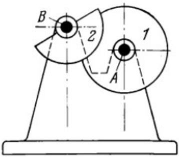
SL
SD



Disks *1* and *2* can turn about fixed axes *A* and *B* and each has an arc-shaped recess of the same radius. When either disk is in rotation the other disk is locked against rotation, i.e. simultaneous rotation of the disks is impossible.

331 INTERLOCKING DEVICE

SL
SD



Disk *1* has an arc-shaped recess and can turn about fixed axis *A*. Semidisk *2* can turn about fixed axis *B*. Disk *1* is locked against rotation when semidisk *2* is turned so that it enters the recess, which is of the corresponding shape, in disk *1*.

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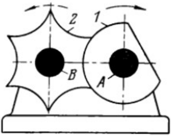
332 INTERLOCKING DEVICE

SL
SD

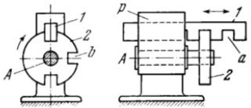


Disk *1* has a segment cut off and can turn about fixed axis *A*. Disk *2* has six symmetrically arranged arc-shaped recesses and can rotate about fixed axis *B*. Disk *2* is locked against rotation when the circular part of disk *1* enters one of the recesses, which are of the corresponding shape, in disk *2*. Disk *2* can rotate when disk *1* is turned so that its flat part faces disk *2*.

333

INTERLOCKING DEVICE

SL
SD

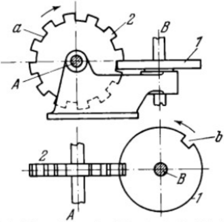


Rack *1* with slots *a* slides in fixed guide *p*. Disk *2* with slots *b* can turn about fixed axis *A*. Slots *a* of rack *1* are slightly wider than disk *2* and slots *b* of disk *2* are slightly wider than rack *1*. In its reciprocating motion, rack *1* periodically locks disk *2* against rotation; disk *2* in rotation periodically locks rack *1* against reciprocation so that their simultaneous motion is impossible.

334

INTERLOCKING DEVICE

SL
SD



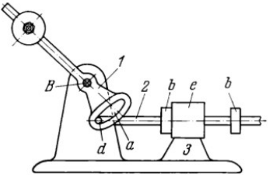
Disk *1* with slot *b* can turn about fixed axis *B*; disk *2* with slots *a* can turn about fixed axis *A*. In rotation, disk *1*, whose slot *b* is slightly wider than disk *2*, periodically locks disk *2* against rotation. In rotation, disk *2* whose slots *a* are slightly wider than disk *1*, locks disk *1* against rotation, so that simultaneous rotation of the disks is impossible.

6.* SWITCHING, ENGAGING AND DISENGAGING MECHANISMS (335 through 361)

335

SWITCHING LEVER

SL
SE

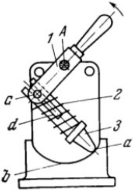


Lever *1*, weighted to hold it in its extreme positions, has slot *a* of specially designed noncircular shape and turns about fixed axis *B*. Pin *d*, in slot *a*, is rigidly secured to rod *2* which slides in guide *e* of base *3*. Two shoulders *b* limit the travel of rod *2*. Rod *2* is shifted to and held in its extreme positions by turning lever *1* about axis *B*.

336

SWITCHING LEVER WITH A COMPLEX-MOTION LINK

SL
SE



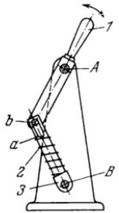
Lever *1* turns about fixed axis *A* and its pin *c* enters slot *d* of link *3*. Tip *a* of link *3* slides along contoured raceway *b* of the base. When lever *1* is turned, link *3* is shifted from one stable position to the other, passing through the unstable position in which lever *1* is vertical and spring *2* is compressed the maximum amount.

337

SWITCHING LEVER WITH A TURNING MEMBER

SL

SE



Lever *1* turns about fixed axis *A* and its pin *b* slides along slot *a* of link *3* which turns about fixed axis *B*. When lever *1* is turned, pin *b* shifts link *3* from one extreme position to the other. Spring *2* applies the force to hold the device in its extreme positions.

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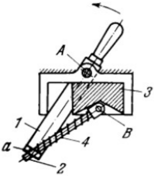
338

SWITCHING LEVER FOR A MEMBER WITH TRANSLATIONAL MOTION

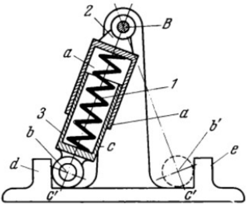
SL

SE



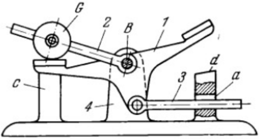
When lever *1* is turned about fixed axis *A*, rod *2* slides in hole *a* of lever *1*. At this, link *3*, connected by turning pair *B* to rod *2*, is shifted from one extreme position to the other. Spring *4* applies the force to hold the device in its extreme positions.

339 SWITCHING LEVER SL SE



Link *2*, turning about fixed axis *B*, is designed as sleeve *a*. Link *3*, in the form of sleeve *c*, has head *b* which slides along flat surface *c'*-*c'*. Sleeve *c* slides in sleeve *a*, compressing spring *1* enclosed in the sleeves. In the position shown in the drawing head *b* contacts stop *d*. After being switched, head *b* takes position *b'*, contacting stop *e*.

340 SWITCHING LEVER SL SE



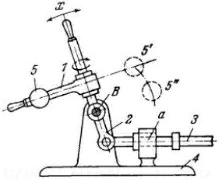
Two-armed lever *1* is linked to rod *3* which slides with considerable clearance in guide *a*. Lever *2* can turn independently of lever *1* about fixed axis *B*. Rod *3* is locked in its extreme positions by shifting lever *2* with its adjustable weight *G*. At this, lever *1* is held against one of the stops, *c* or *d*, of base *4*.

341

SWITCHING LEVER

SL

SE

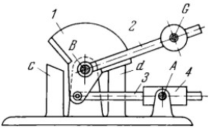


Lever *1* with weight *5* turns about axis *x*. Lever *2* turns about fixed axis *B* and is linked to rod *3* which slides with considerable clearance in guide *a*. To shift rod *3* to its extreme left-hand position, the weight is transferred from position *5* to position *5'* by turning lever *1* about longitudinal axis *x* of lever *2*. After this weight *5* will be shifted by gravity to position *5"*, shifting lever *2* about pin *B*.

342

SWITCHING LEVER

SL
SE



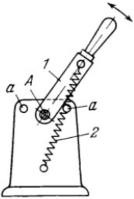
Sector *1* is hinged to rod *3* which slides in guide *4*. Guide *4* turns about fixed axis *A*. Lever *2* turns about fixed axis *B* independently of sector *1*. Rod *3* is shifted from one extreme position to the other by turning lever *2* with weight *G* about axis *B*. At this, sector *1* is held by weighed lever *2* against one of the stops, *c* or *d*, of the base.

343

SWITCHING LEVER

SL
SE

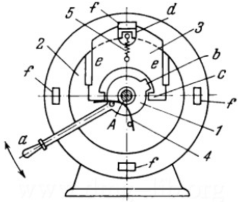
Lever *1*, turning about fixed axis *A*, is shifted from one extreme position to the other. Spring *2* holds lever *1* against one of the stops *a*.



344

SWITCHING LEVER

SL
SE



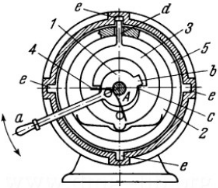
Link *1*, having lever *a*, turns about fixed axis *A*. Link *1* has projection *b* which engages lug *c* of latch *3* when lever *a* is turned. Latch *3* slides in guides *e-e* of link *2*. The base has an annular member with projections *f*. In any of the engaged positions, slot *d* of latch *3* slides over the corresponding projection *f*. When lever *a* is turned in either direction, latch *3* is disengaged from the base and link *2* is shifted by spring *4* to its next position. Spring *5* applies force to hold the device in an engaged position.

345

SWITCHING LEVER

SL

SE



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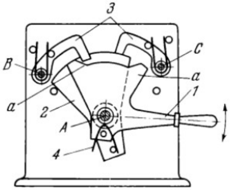
Link *1*, having lever *a*, turns about fixed axis *A*. Link *1* has projection *b* which engages shoulder *c* of latch *3* when lever *a* is turned. Latch *3* has pin *d* which slides in a radial slot of ring *5*. The base has slots *e*. When lever *a* is turned, projection *b* of link *1* engages shoulder *c* of latch *3*, disengaging the latch from the base. At this link *2*, together with ring *5*, is shifted by spring *4* to its next position.

346

SWITCHING LEVER

SL
SE

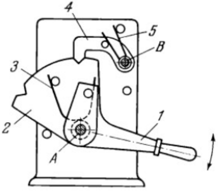


Lever *1* and sector *2* turn independently of each other about fixed axis *A*. When lever *1* is turned its projections *a* disengage right- or left-hand pawl *3* from sector *2*. Pawls *3* turn about fixed axes *B* and *C*. Sector *2* is shifted by spring *4* from one position to the other.

347

SWITCHING LEVER

SL
SE



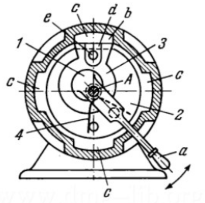
Lever *1* and sector *2* turn independently of each other about fixed axis *A*. When lever *1* is turned sector *2* is shifted by spring *3* to one or the other position indexed by pawl *4* which turns about fixed axis *B* and is held against sector *2* by spring *5*.

348

SWITCHING LEVER WITH AN ECCENTRIC CAM

SL

SE

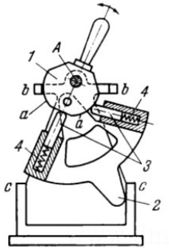


Eccentric cam *1*, turning about fixed axis *A*, has handle *a*. Eccentric cam *1* fits into a hole in latch *3* whose end enters slot *c* of the base. Latch *3* has slot *d* which slides along pin *e* of link *2*. When lever *a* is turned in either direction, latch *3* is disengaged from the base and link *2* is shifted by spring *4* to its next position.

349

SWITCHING LEVER

SL
SE

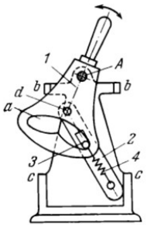


Lever *1*, turning about fixed axis *A*, has two symmetrical contoured portions *a* which alternately actuate plungers *3*, sliding in guides of link *2*. When lever *1* is turned, link *2* is shifted from one extreme position to the other with a stop in the middle position. Each extreme position corresponds to a position of lever *1* up against one of the stops *b* and a position of link *2* up against one of the stops *c*. Springs *4* apply forces to hold the device in its extreme positions

350

SWITCHING LEVER

SL
SE

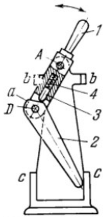


Lever *1*, turning about fixed axis *A*, has slot *a* of special shape which actuates pin *3*. Pin *3* slides along a guide of link *2*. Link *2* is connected by turning pair *d* to lever *1*. When lever *1* is turned, link *2* is shifted from one extreme position to the other. Each extreme position corresponds to a position of lever *1* up against one of the stops *b* and a position of link *2* up against one of the stops *c*. Spring *4* applies force to hold the device in its extreme positions.

351 SWITCHING LEVER

SL

SE

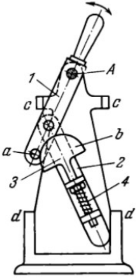


Lever *1* turns about fixed axis *A*. Plunger *3*, sliding in a guide in lever *1*, actuates the contoured end *a* of lever *2* which is connected by turning pair *D* to lever *1*. When lever *1* is turned, lever *2* is shifted from one extreme position to the other. Each extreme position corresponds to a position of lever *1* up against one of the stops *b* and a position of lever *2* up against one of the stops *c*. Spring *4* applies force to hold the device in its extreme positions.

352 SWITCHING LEVER

SL

SE



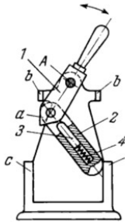
Lever *1* turns about fixed axis *A*. Pin *a* of lever *1* actuates contoured end *b* of link *3* which slides along guides of link *2*. When lever *1* is turned, link *2* is shifted from one extreme position to the other. Each extreme position corresponds to a position of lever *1* up against one of the stops *c* and a position of link *2* up against one of the stops *d*. Spring *4* applies force to hold the device in its extreme positions.

353

SWITCHING LEVER

SL

SE



Lever *1* turns about fixed axis *A* and has contoured end *a* which actuates plunger *3* sliding along the guide of link *2*. When lever *1* is turned, link *2* is shifted from one extreme position to the other. Each extreme position corresponds to a position of lever *1* up against one of the stops *b* and a position of link *2* up against one of the stops *c*. Spring *4* applies force to hold the device in its extreme positions.

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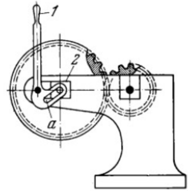
354

ENGAGING LEVER FOR GEARS

SL

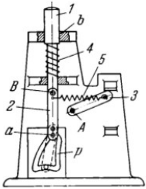
SE



When lever *1* is turned its slot *a* shifts slide block *2* along a slot and engages or disengages the gears. Slot *a* is designed with a shape to provide the required motion for putting the gears into mesh.

355 PUSH-BUTTON ENGAGING MECHANISM

SL
SE

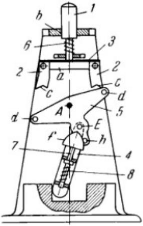


Link *1*, designed as a push button, slides in fixed guides *b* and is held in its upper position by spring *4*. Link *2* is connected by turning pair *B* to link *1* and has, at its end, pin *a* which slides along fixed slot *p*. Link *3*, turning about fixed axis *A*, is connected by spring *5* to link *2*. When button *1* is pressed, pin *a* of link *2* slides along slot *p* and shifts link *3* from one extreme position to the other. After the button is pressed for the first time link *2* is in the position shown by the dash lines. Link *3* is shifted back to its initial position by pressing the button again.

356

PUSH-BUTTON ENGAGING MECHANISM

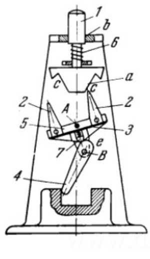
SL
SE



Link *1*, designed as a push button, slides in fixed guides *b* and has crossbar *a* to which links *2* are hinged. Links *2* are held in the position shown in the drawing by flat spring *3*. Button *1* is held in its upper position by spring *6*. Three-armed lever *5* turns about fixed axis *A* and has pins *d* which are engaged by notches *c* of links *2*. Lever *4* is connected by turning pair *E* to lever *5*. Link *7*, ending in head *f*, slides along the axis of lever *4* and is actuated by spring *8*. When button *1* is pressed, three-armed lever *5* is turned by means of links *2* about pin *A*. Pin *h* of lever *5* depresses head *f* of link *7* and shifts lever *4* from one extreme position to the other. The mechanism passes by inertia through the middle neutral position and, as a result, lever *4* is shifted.

357 PUSH-BUTTON ENGAGING MECHANISM

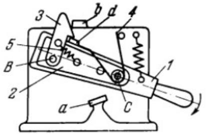
SL
SE



Link *1*, designed as a push button, slides in fixed guides *b*. It is held in its upper position by spring *6* and has head *a* with grooves *c*. Lever *5* turns about fixed axis *A* and has hinged links *2* which are held in the position shown in the drawing (with respect to lever *5*) by flat spring *3*. Spring-loaded pin *7* slides in lever *5* and contacts head *e* of lever *4* which is connected by turning pair *B* to lever *5*. When button *1* is pressed, lever *5* is turned by means of links *2* about pin *A* and pin *7* slides along head *e* of lever *4* shifting the lever from one extreme position to the other. The mechanism passes by inertia through the middle neutral position and, as a result, lever *4* is shifted.

358 ENGAGING AND DISENGAGING LEVER

SL
SE

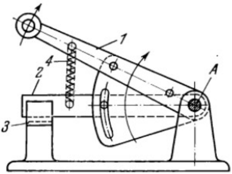


Lever *1* and link *2* turn independently of each other about fixed axis *C*. Latch *3* is connected by turning pair *B* to link *2* and, by the action of spring *5*, snaps over stop *d* of lever *1*. When lever *1* is turned clockwise, latch *3* is disengaged by stop *b* and link *2*, being released, is turned together with latch *3* by flat spring *4* about axis *C* until it reaches stop *a*.

359

LEVER-TYPE TRIP

SL
SE

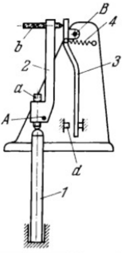


When lever *1* is turned clockwise about fixed axis *A*, blade *2*, attracted by electromagnet *3*, remains in the position shown in the drawing until the tension of spring *4* overcomes the force of attraction. Then blade *2* is turned by lever *1* and the circuit is disconnected.

360

LEVER-TYPE MECHANISM OF A THERMAL SWITCH

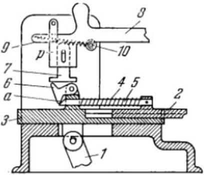
SL
SE



Lever *2*, turning about fixed axis *A*, has two screws, *a* and *b*, which serve to adjust the angles of rotation of the links of the mechanism. Lever *3* turns about fixed axis *B*. Force is applied by spring *4* to hold the mechanism in the closed position. Screw *a* is in contact with rod *1* which is immersed in the medium being heated. As the temperature is raised rod *1* expands, actuating screw *a* of lever *2*. This turns lever *2* about axis *A* and screw *b* turns lever *3* about axis *B* so that the lower end of lever *3* swings from the contact to stop *d*, thereby opening the circuit that heats the medium.

361

LEVER-TYPE MECHANISM FOR DISENGAGING A DRIVE

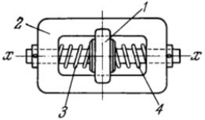


Oscillating lever *1* imparts reciprocating motion to slide *2* through slide *3*, rod *5* and spring *4* which is designed for a definite tension. When slide *2* is overloaded and the resistance to its motion exceeds the tension of spring *4*, lever *1*, in its travel to the right, compresses spring *4*. At this pawl *6* slides along bevelled end *a* of rod *5* and raises latch *7* which slides in fixed guide *p*. Latch *7* disengages lever *8* from pin *10*. Spring *9* shifts lever *8* to the right, thereby disengaging the drive.

7. INDEXING MECHANISMS (362 through 405)

362 SPRING-TYPE LOCATING DEVICE

SL
I



Member *1* slides along axis *x-x*. The position of sliding member *1* with respect to frame *2* is determined by springs *3* and *4*.

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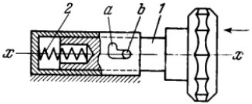
363 INDEXED KNOB

SL
I

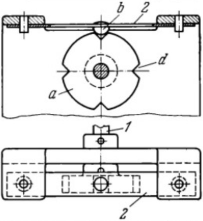


Knob *1* turns about and slides along axis *x-x*. It has pin *b* which slides along profiled slot *a*. Knob *1* is actuated by spring *2*. To put the knob into the indexed position it is pushed along axis *x-x* and then turned about this axis.

364

SPRING-TYPE INDEXING DEVICE

SL
I

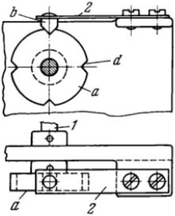


Link *1*, having disk *a* with four V-shaped slots *d*, is indexed in four positions by flat spring *2* having round button *b* which enters slots *d*.

365

SPRING-TYPE INDEXING DEVICE

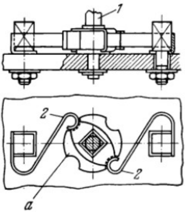
SI
I



Link *1*, having disk *a* with four V-shaped slots *d*, is indexed in four positions by flat spring *2* having V-shaped pin *b* which enters slots *d*.

366 SPRING-TYPE INDEXING DEVICE

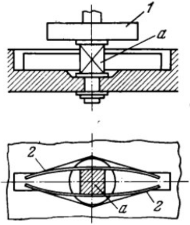
SL
I



Link *1*, having disk *a* with four semicircular slots, is indexed in four positions by shaped springs *2*.

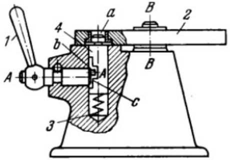
367 SPRING-TYPE INDEXING DEVICE

SL
I



Link *1* is indexed in four positions per revolution by flat springs *2* which contact the sides of square *a* on link *1*.

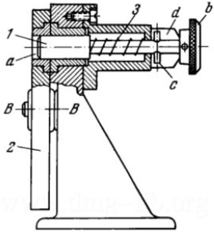
368 LEVER-TYPE INDEXING DEVICE



Lever *1* turns about fixed axis *A*. On its end face the shaft of lever *1* has eccentrically located pin *b*. Indexing plunger *4* slides in a fixed guide and is actuated by spring *3*. Disk *2* turns about vertical fixed axis *B* and has a number of holes *a*. Disk *2* is locked in its indexed positions by indexing plunger *4* which enters one hole *a* of the disk due to the action of spring *3*. When lever *1* is turned, pin *b* engages side *c* of the slot in plunger *4*. This depresses the plunger, withdrawing it from hole *a*.

369 LEVER-TYPE INDEXING DEVICE

SL
I

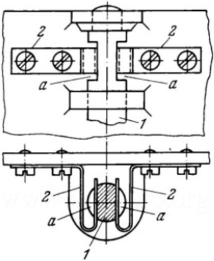


Disk *2* turns about fixed axis *B* and has a number of holes *a*. Indexing plunger *1* slides in a fixed guide and is actuated by spring *3*. Plunger *1* has pin *c* which slides along slot *d*. Disk *2* is locked in its indexed positions by plunger *1* which enters one hole *a* of the disk due to the action of spring *3*. Indexing plunger *1* is withdrawn from hole *a* by pulling knob *b* until pin *c* comes out of slot *d*. Then the plunger is turned 90° to hold it in the retracted position.

370

SPRING-TYPE INDEXING DEVICE

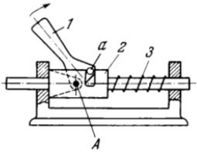
SL I



Link *1*, having two flats *a*, is indexed twice per revolution by flat springs *2* which contact the flats.

371 LOCKING LEVER FOR A ROD

SL I



When lever *1* is turned clockwise about fixed axis *A*, pin *a* of the lever enters a slot of rod *2* and locks it in the given position. When lever *1* is disengaged, rod *2* is returned to the initial position by spring *3*.

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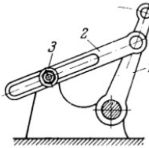
372 LOCKED LEVER

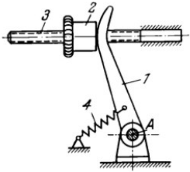
SL I



Lever *1* is set in the required position by means of link *2* whose slot slides along bolt *3* which is used to lock link *2* and lever *1*.

373 ADJUSTABLE-POSITION LEVER

SL
I



Lever *1* turns about fixed axis *A*. Lever *1* is set to the required position by adjusting thumb nut *2* along screw *3*. Spring *4* applies force to hold lever *1* in the adjusted position.

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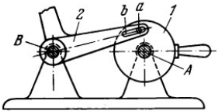
374 ADJUSTABLE-POSITION LEVER

SL
I

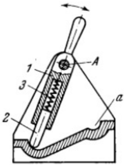


Disk *1*, turning about fixed axis *A*, has pin *a* which slides in straight slot *b* of lever *2* whose position is to be adjusted. Lever *2* turns about fixed axis *B*. Disk *1* is turned to set lever *2* to the required position and is secured to hold the lever in the adjusted position.

375

INDEXING LEVER

SL
I



Lever *1*, turning about fixed axis *A*, has plunger *2* actuated by spring *3*. Lever *1* is automatically indexed to the left-hand position shown in the drawing. When the lever is shifted to the right-hand position it is held in this position by means of spring *3* and plunger *2* which enters recess *a*.

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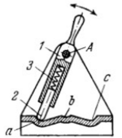
376

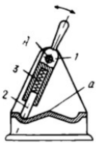
INDEXING LEVER

SL
I



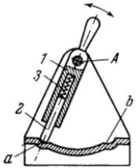
Lever *1*, turning about fixed axis *A*, has plunger *2* actuated by spring *3*. Lever *1* can be shifted to any of three indexed positions and is held in that position by spring *3* and plunger *2* which enters the corresponding recess, *a*, *b* or *c*.

377 INDEXING LEVER SL I



Lever *1*, turning about fixed axis *A*, has plunger *2* actuated by spring *3*. Lever *1* is automatically indexed to the right- or left-hand position after plunger *2* passes over projection *a*.

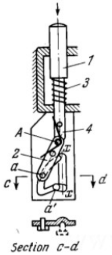
378 INDEXING LEVER SL I



Lever *1*, turning about fixed axis *A*, has plunger *2* actuated by spring *3*. Lever *1* can be shifted from its neutral position to either of two indexed positions and is held in that position by spring *3* and plunger *2* which enters the corresponding recess, *a* or *b*.

379 INDEXED PUSH BUTTON

SL
I



When push button *1* is pressed downward, pin *a*, secured on link *2*, slides along a curvilinear slot to position *a'*. This is the indexed lower position of the push button. Link *2* is connected by turning pair *A* to the shank of push button *1*. When push button *1* is pressed a second time, pin *a* is transferred from the curvilinear slot to straight slot *x-x* and push button *1* is returned to its upper position by spring *3*.

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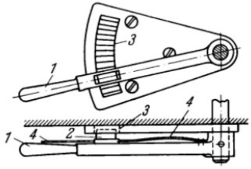
380 INDEXING LEVER

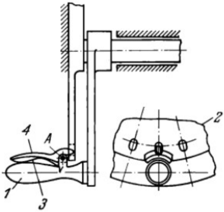
SL
I



Lever *1* is held in any indexed position by catch *2* which enters the corresponding slot of member *3*. Catch *2* is actuated by flat spring *4*.

381 INDEXING LEVER

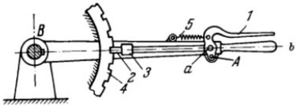
SL I



Lever *1* is held in any indexed position by catch *4* which turns about axis *A* and is actuated by flat spring *3*. The right-hand end of catch *4* enters the corresponding hole of fixed member *2*.

382 INDEXING LEVER

SL I



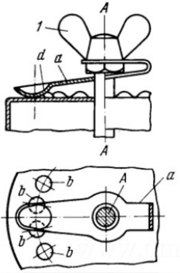
Lever *b* turns about fixed axis *B*. When lever *b* is to be shifted, its member *1* is pressed with the hand, turning this member about pin *A*. This withdraws latch *2* which is connected by pin *a* to member *1* and slides with a certain clearance in guide *3*. In the required shifted position of lever *b* member *1* is released and spring *5* returns latch *2* into the corresponding slot of segment *4*.

383

INDEXING DEVICE WITH AN ELASTIC MEMBER

SL

I



Wing knob *1*, turning about fixed axis *A*, has elastic member *a* whose end *d* is of convex shape. Wing knob *1* is held in the required indexed position by the end of member *a* which seats itself between the corresponding two round buttons *b* of the base.

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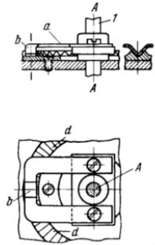
384

INDEXING DEVICE WITH AN ELASTIC MEMBER

SL

I

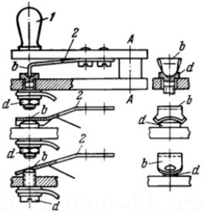


Link *1*, turning about fixed axis *A*, has elastic member *a* whose end *b* enters one of the radial V-shaped slots *d* of the base. Link *1* is held in the required indexed position by end *b* of member *a* when it enters the corresponding slot *d*.

385

INDEXING DEVICE WITH AN ELASTIC MEMBER

SL
I



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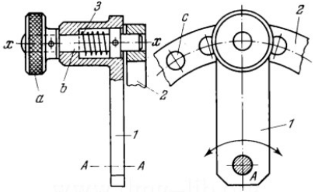
Lever *1*, turning about fixed axis *A*, has elastic member *2* whose end *b* engages link *d* of the base. Lever *1* is held in the required indexed position by end *b* which engages the corresponding link *d*. The drawing shows several design versions of member *2* and link *d*.

INDEXING HANDLE



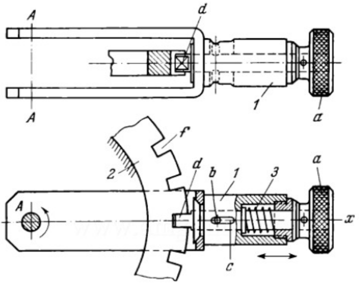
Handle *1* turns about fixed axis *A*. Knob *a* has pin *b* whose end enters round holes *c* in fixed plate *2*. To withdraw pin *b* from a hole *c* it is necessary to pull knob *a* along axis *x-x*, overcoming the resistance of spring *3*. After this, handle *1* can be turned about axis *A*; it is held in the required indexed position by pin *b* which enters the corresponding hole *c* when knob *a* is released.

387

INDEXING HANDLE

SL

I

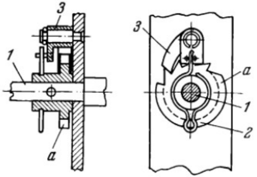


Handle *1* turns about fixed axis *A*. Knob *a* has pin *b* which slides along slot *c*, and plunger *d* which enters slots *f* in stationary quadrant *2*. To withdraw plunger *d* from a slot *f*, it is necessary to pull knob *a* along axis *A-x*, overcoming the resistance of spring *3*, by an amount permitted by slot *c*. After this, handle *1* can be turned about axis *A*; it is held in the required indexed position by plunger *d* which enters the corresponding slot *f* when knob *a* is released.

388

RATCHET-TYPE INDEXING DEVICE WITH A SPRING MEMBER FOR A SHAFT

SL
I



Ratchet wheel *a* is secured rigidly on shaft *1*. They are held in the required indexed position by pawl *3* which is actuated by shaped spring *2*.

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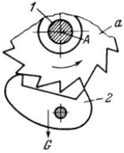
389

RATCHET-TYPE INDEXING DEVICE FOR A SHAFT

SL
I



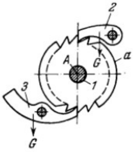
Ratchet wheel *a* is secured rigidly on shaft *1*. They can turn about fixed axis *A* and are held in the required indexed position by pawl *2* which is actuated by its own weight *G*.

390

RATCHET-TYPE INDEXING DEVICE WITH TWO PAWLS FOR A SHAFT

SL

I



Ratchet wheel *a* is secured rigidly on shaft *1*. They can turn about fixed axis *A* and are held in the required indexed position by pawls *2* and *3* which are actuated by their own weights *G*.

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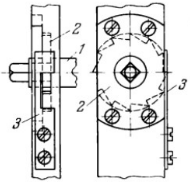
391

SPRING-TYPE INDEXING DEVICE FOR A SHAFT

SL

I

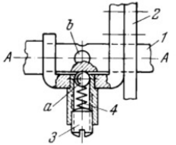


Ratchet wheel *2* is secured rigidly on shaft *1*. They are held in the required indexed position by flat spring *3*.

392 BALL-CLICK INDEX

SL

I

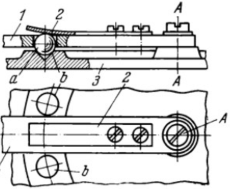


Link *2*, turning about fixed axis *A*, is held in the required indexed position with respect to shaft *1* by ball *a* which enters the corresponding recess *b* in the shaft. The index is adjusted by setscrew *3* which varies the compression of spring *4* actuating ball *a*.

393 END-TYPE BALL-CLICK INDEX

SL

I

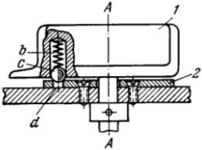


Link *1*, turning about fixed axis *A*, is held in the required indexed position with respect to fixed link *3* by ball *a* which enters the corresponding recess *b* on the end face of link *3*. The index is adjusted by flat spring *2*.

394

END-TYPE BALL-CLICK INDEX

SL
I



Link *1*, turning about fixed axis *A*, has ball *c* actuated by spring *b*. Link *1* is held in the required indexed position by ball *c* which enters the corresponding hole *d* located on the end face of fixed disk *2*.

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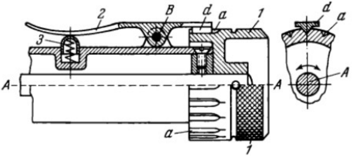
395

INDEXED THIMBLE

SL
I



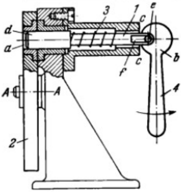
Thimble *1*, turning about fixed axis *A*, has grooves *a*. Lever *2*, turning about fixed axis *B*, has projection *d* and is actuated by spring *3*. To turn thimble *1*, lever *2* is turned counterclockwise about pin *B*, overcoming the resistance of spring *3*. Thimble *1* is held in the required indexed position by projection *d* which enters the corresponding groove *a*.

396

LEVER-TYPE ECCENTRIC-CAM INDEXING DEVICE FOR A DISK

SL

I



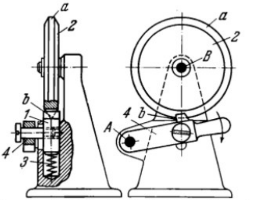
At one end of lever *4* is eccentric cam *b* which slides along fixed flat surface *c-c* when lever *4* is turned. Pin *e* of the eccentric cam is in slot *f* of link *1* which has plunger *d* at its other end. Spring *3* is arranged between the plunger and its fixed housing. Disk *2*, turning about fixed axis *A*, has holes *a*. Disk *2* is held in the required indexed position by plunger *d* of link *1* which enters the corresponding hole *a* of the disk, being actuated by spring *3*. When lever *4* is turned counterclockwise, eccentric cam *b* withdraws plunger *d* from hole *a*.

397

LEVER-TYPE FINE-ADJUSTMENT INDEXING DEVICE FOR A DISK

SL

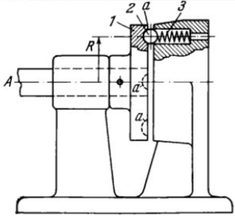
I



Lever *4*, turning about fixed axis *A*, is linked to plunger *b* which is actuated by spring *3*. Disk *2*, turning about fixed axis *B*, has bevelled rim *a*. Disk *2* is held in the required adjusted position by plunger *b* which fits over and wedges rim *a* of the disk under the action of spring *3*. When lever *4* is turned clockwise, plunger *b* is lowered and disk *2* is released.

398 BALL-CLICK INDEX FOR A DISK

SL
I

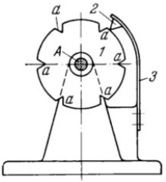


Disk *1*, turning about fixed axis *A*, has recesses *a* located on a circle of radius *R*. Disk *1* is held in the required indexed position by ball *2* which enters the corresponding recess *a*. Ball *2* is held in recess *a* by the action of spring *3*.

399

INDEXING DEVICE FOR A DISK

SL
I



Disk *1*, turning about fixed axis *A*, has grooves *a*. Flat spring *3*, secured rigidly on the base, has V-shaped member *2* at its end. Disk *1* is held in the required indexed position by member *2* which enters the corresponding groove *a* of disk *1*.

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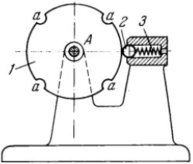
400

BALL-CLICK INDEX FOR A DISK

SL
I

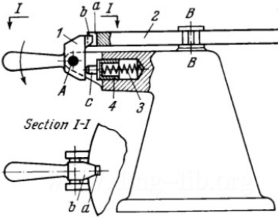


Disk *1*, turning about fixed axis *A*, has arc-shaped grooves *a* on its circumference. Disk *1* is held in the required indexed position by ball *2* which enters the corresponding groove *a* of disk *1*. Spring *3* holds ball *2* against disk *1*.

401

LEVER-TYPE INDEXING DEVICE FOR A DISK

SL I

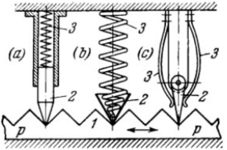


Handle *1*, turning about fixed axis *A*, has latch *b*. Plunger *4*, sliding in a fixed guide, has pin *c* which slides along a flat surface of handle *1*. Plunger *4* is actuated by spring *3*. Disk *2*, turning about vertical fixed axis *B*, has grooves *a* around its circumference. Disk *2* is held in the required indexed position by handle *1* whose latch *b* enters the corresponding groove *a* of disk *2* due to the action of spring *3*. When handle *1* is turned counterclockwise it releases disk *2*.

402

INDEXING DEVICE FOR A RACK

SL
I



Toothed rack *1* slides along fixed guide surface *p-p*. Link *2* enters the corresponding tooth-space of rack *1* where it is held by the action of spring *3*. Rack *1* can be held in the required indexed position by one of the design versions, *a*, *b* or *c*, shown in the drawing.

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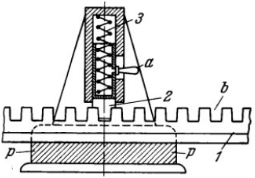
403

INDEXING DEVICE FOR A RACK

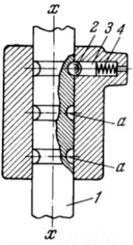
SL
I



Toothed rack *1* slides along fixed guide surface *p-p*. Plunger *2* enters the corresponding tooth-space of rack *1* where it is held by the action of spring *3*. Plunger *2* has handle *a* by means of which it is disengaged from the rack. Plunger *2* holds the rack in the required indexed position.

404 BALL-CLICK INDEX FOR A SHAFT

SL
I



Shaft *1* can turn about fixed axis *x-x* and slide along this axis. Shaft *1* is held in the required indexed axial position by ball *2* which enters the corresponding annular groove *a*. Through plunger *3*, spring *4* holds ball *2* in groove *a*.

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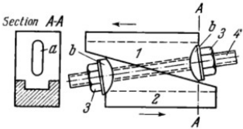
405 SCREW-TYPE LOCKING DEVICE FOR WEDGES

SL
I

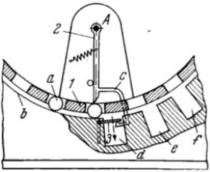


Wedges *1* and *2* have elongated holes *a* through which screw *4* passes. At the ends of screw *4* are nuts *3* and washers *b* with one arc-shaped end. Wedges *1* and *2* are locked in the required position by tightening nuts *3* on screw *4*.

8. SORTING AND FEEDING MECHANISMS
(406 through 429)

406 LEVER-TYPE SORTING MECHANISM

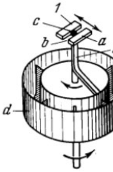
SL
SF



Workpieces *a* being inspected are moved along circular surface *b* of the base by continuously revolving wheel *1*. If workpiece *a* is oversize it will deflect lever *2* when it passes under the sharp measuring edge of the lever. Lever *2* turns about fixed axis *A* and, when deflected, its latch *c* releases cover *3* of hatch *d*. Thus oversize workpieces drop through hatch *d*. If workpiece *a* is undersize it passes freely under lever *2* and drops through the next hatch *e* which is too small for workpieces of the proper size. Workpieces of the proper size pass hatches *d* and *e* and drop through hatch *f*. In this way, the workpieces are sorted into three size groups.

407 LEVER-TYPE SORTING MECHANISM

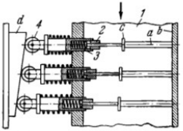
SL
SF



Movable measuring jaw *1* reciprocates, moving toward and away from stationary jaw *a*, decreasing and increasing opening *b* of the gauge. Workpieces *c* being sorted pass through the opening *b* of the gauge and drop onto chute *2*, which rotates synchronously with the reciprocation of jaw *1*. This distributes the workpieces into size groups in the compartments of hopper *d*.

408 LEVER-TYPE SORTING MECHANISM WITH AN ELASTIC LINK

SL
SF



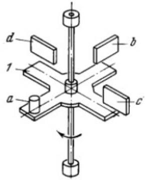
This mechanism is intended for sorting tubes according to length. From the loading device, tubes *a* being sorted drop into slots of straight-line conveyer *1*. One end of the tubes bears against disk *b* at the side of conveyer *1*. The other end of the tubes bears against buttons *c* mounted in cartridges *2*. The buttons are held against the tubes by springs *3*. Rollers *4*, mounted on cartridges *2*, roll along fixed cam *d* when the conveyer is in motion and set the cartridges at various distances from disk *b*. Tubes *a*, clamped between buttons *c* and disk *b*, are released, according to their length, at a definite point on cam *d* and drop into the corresponding hopper. By changing cam *d* the device can be set up to operate with different sorting ranges; by adjusting the position of disk *b* it can be set up for different tube lengths.

409

LEVER-TYPE SORTING MECHANISM

SL

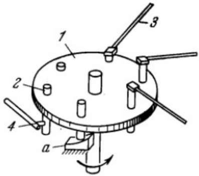
SF



Workpiece *a* is placed on and turns with multiple-armed member *1*. Stationary jaws *d*, *b* and *c* are set above member *1* at decreasing heights. As member *1* rotates, oversize workpieces *a* are swept off by jaw *d*, workpieces of proper height by jaw *b* and undersize workpieces by jaw *c*. They drop into the corresponding hoppers.

410 LEVER-TYPE SORTING MECHANISM

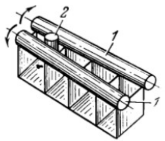
SL
SF



Disk *1* rotates synchronously with the conveying system (not shown in the drawing) which carries the workpieces being sorted from one measuring station to the next. Disk *1* has holes accommodating rods *2*. The number of rods *2* equals the number of sockets of the conveying system. Arranged around disk *1* are levers *3* of a number equal to the number of measuring stations. At the moment of inspection of a workpiece that is to be rejected, lever *3*, linked to the measuring system, pushes the corresponding rod *2* downward. Rod *2*, remaining in this position, is carried by disk *1* and, when the rejected workpiece, lying on the conveyer system, approaches the sorting station, rod *2* closes contact *4* and an operative member ejects the off-size workpiece from the conveying system. Upon further rotation of disk *1*, fixed guide *a* returns rod *2* to its initial position.

411 SORTING DEVICE FOR ROLLERS

SL
SF



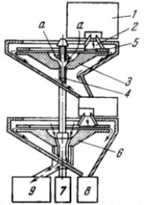
This mechanism is intended for sorting tapered rollers. Shafts *1* rotate in opposite directions and their axes diverge. They are inclined at an angle of 20° to the horizontal. By the action of gravity tapered rollers *2* slide along rotating shafts *1* and drop through between them at the points corresponding to their size.

412

SORTING DEVICE FOR CYLINDRICAL WORKPIECES

SL

SF



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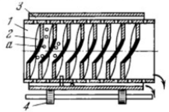
This device sorts cylindrical workpieces into three size groups: oversize, within-size and undersize (rejects). The workpieces are dumped into hopper *1* and are fed out, one by one, along chute *2*, onto rotating disk *3* mounted on spindle *4*. By centrifugal force the cylindrical workpieces are forced outward to the precise gap between disk *3* and ring *5*. The within-size and undersize workpieces pass through the gap and along a chute to the second disk *6*. The oversize workpieces are removed by a stripper (not shown in the drawing) and they drop through a hole in spindle *4* into hopper *7*. The within-size and undersize workpieces are forced outward by centrifugal force to the precise gap. Only the undersize workpieces (rejects) pass through the gap and roll down the casing into hopper *8*. The within-size workpieces are removed by a stripper (not shown) and drop into hopper *9*.

413

SCREW-TYPE SORTING DEVICE

SL
SF

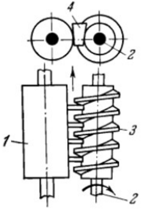


This mechanism sorts rings cut off of tubes. Cylinder *1* with internal screw member *2* has holes *a* throughout its surface and is arranged inside of cylinder *3* which has no such holes. Cylinder *3* lies on rollers *4* and both cylinders rotate about an inclined axis. Workpieces (tube pieces) are loaded into the left-hand end of cylinder *1* and as it rotates they are moved by screw member *2* along cylinder *1*. Longer workpieces, dropping into holes *a* bear against cylinder *3* and cannot get into the space between the cylinders. Shorter workpieces (rings) drop through the holes and slide along between the cylinders, being thereby separated from the longer workpieces. Holes *a* may be made of various shapes, therefore the mechanism can sort workpieces according to either their shape or their size.

414

SCREW-TYPE SORTING DEVICE

SL
SF

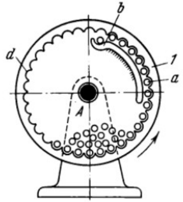


Fixed shafts *1* and *2* with non-parallel axes form a wedge-type gauge. Conveyer screw *3*, rotating about shaft *2*, moves workpieces *4* along the gap of the wedge-type gauge. Workpieces *4* drop through the gap at the places corresponding to their size.

415 BLANK FEEDING DEVICE

SL

SF



Drum *1*, rotating about fixed axis *A*, has recesses *d* on its inner surface. Upon rotation of drum *1*, blanks *a* are carried to chute *b* which leads to the feeding unit of the machine tool.

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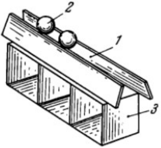
416 BALL SORTING DEVICE

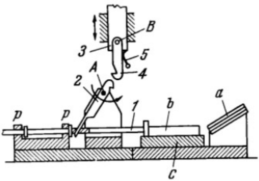
SL

SF



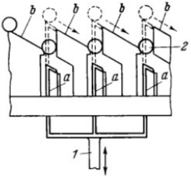
This mechanism is intended for sorting balls according to their size. Balls *2* roll by gravity between diverging blades *1* which are inclined to the horizontal. Depending upon their size, the balls drop through the gap into one of the hoppers *3*.

LEVER-TYPE FEEDING MECHANISM



Plunger *3* slides in a fixed guide. Lever *4*, connected by turning pair *B* to plunger *3*, is actuated by flat spring *5*. Lever *2* turns about fixed axis *A*. Plunger *1* slides in fixed guides *p*. From chute *a* workpiece *b* slides onto fixed surface *c*. After being machined, workpiece *b* is ejected by plunger *1*, actuated by lever *2*, as follows. As plunger *3* descends, lever *4* is pushed back by lever *2*. In the return stroke of plunger *3*, lever *4*, returned to its initial position by spring *5*, engages the tooth of lever *2*, turning the lever about axis *A*. In turning, lever *2* advances plunger *1* which ejects the workpiece.

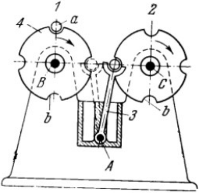
LEVER-TYPE SORTING MECHANISM



Pushers *a* are rigidly secured to link *1* which has a vertical reciprocating motion. In the upward stroke of link *1* pushers *a* raise workpieces *2* which roll down by gravity along inclined surfaces *b*. The gaps at the bottom of the inclined surfaces gradually increase so that the workpieces drop through according to their size and are thereby sorted.

419 LEVER-TYPE FEEDING DEVICE

SL
SF

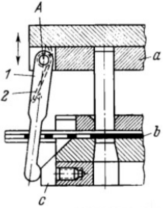


Lever *3*, designed as a fork, turns about fixed axis *A*. Disks *2* and *4* rotate about fixed axes *C* and *B*. This mechanism is intended for transferring workpieces *a* from one inspecting operation to the next. Disk *4*, turning about horizontal axis *B*, picks up workpiece *a* with its grooves *b* and carries it to the measuring device (not shown in the drawing) located at the upper point of disk *4* where the inspecting operation is performed. Then disk *4* turns 90° and workpiece *a* is picked up by the fork of rocking lever *3* and transferred to disk *2* where another measuring device performs an inspecting operation.

420

LEVER-TYPE FEEDING MECHANISM

SL
SF



Lever *1* turns about axis *A* of upper shoe *a*. Flat spring *2* tends to hold lever *1* in the vertical position. In the working stroke, lever *1*, together with the whole upper die, descends, passing through the next hole punched in strip *b*. The lower end of lever *1* runs against a bevel on lower die *c* and slides along this bevel, thereby advancing strip *b* the required amount.

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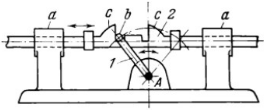
421

LEVER-TYPE INTERMITTENT FEED MECHANISM

SL
SF

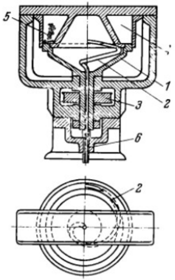


Lever *1*, having pin *b*, oscillates about fixed axis *A*. Link *2*, having projections *c*, has translational motion in fixed guides *a*. In its oscillation, lever *1* imparts intermittent reciprocating motion to link *2*.

422

DEVICE FOR FEEDING SMALL PINS

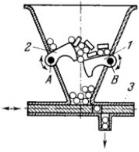
SL
SF



Pulley *3* imparts rotary motion to member *1* together with tube *2* whose end passes through the flange of member *1*. Hopper *4* is filled with pins *5*. As tube *2* moves in hopper *4*, it picks up pins *5* which slide down into stationary tube *6*.

423 LEVER-TYPE BLANK FEEDING MECHANISM

SL
SF



Levers *1* and *2* are oscillated about fixed axes *B* and *A* by a special device not shown in the drawing. By the action of levers *1* and *2*, short cylindrical blanks are oriented into the position required for processing. The blanks pass through the slot formed between the levers and drop into the magazine from where they are transferred by reciprocating member *3* to the feeding device of the machine tool.

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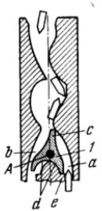
424 LEVER-TYPE BLANK FEEDING MECHANISM

SL
SF

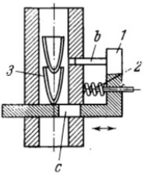


Lever *1*, turning about fixed axis *A*, has arm *c* and two arms *d*. By turning through a certain angle, lever *1* alternately closes channels *a* and *b* with its arm *c*, thereby dividing the stream of blanks into two. Arms *d* bear up against fixed projection *e* and thus locate the extreme positions of lever *1*.

425 LEVER-TYPE BLANK FEEDING MECHANISM

SL

SF



Member *1*, reciprocating in fixed guides, has hole *c* and pin *b*. As member *1* moves to the left, one blank *3* drops through hole *c* into the feeding device. Pin *b* prevents the next blank from dropping through the hole. Spring *2* returns member *1* to its initial position.

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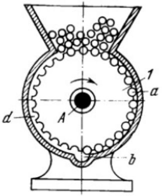
426 BLANK FEEDING MECHANISM

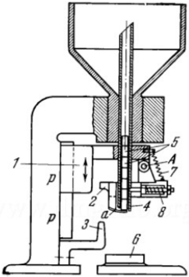
SL

SF



Drum *1*, rotating about fixed axis *A*, has pockets *d* on its circumference. Upon rotation of drum *1*, pockets *d* pick up and carry blanks *a* to slot *b* from where they slide down into the feeding device of the machine.

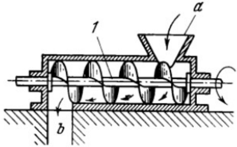
427 LEVER-TYPE LOADING DEVICE SL SF



Sliding member *1*, together with tube *4* and lever *2*, slides along fixed guide *p-p*. When sliding member *1* descends, lever *2*, running against stop *3*, turns about axis *A*. At this, latch *a* is withdrawn from tube *4* and blank *5* is loaded onto feeding device *6*. As sliding member *1* travels upward, lever *2* is returned by spring *7* to its initial position and latch *a* closes off the end of tube *4* which is again filled with blanks. Device *8* holds lever *2* in the correct position.

428 SCREW CONVEYER

SL
SF



In rotation of conveyer screw *1*, material entering the conveyer from bunker *a* is pushed along the axis of the screw and is dumped into channel *b*.

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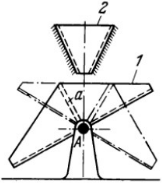
429 LEVER-TYPE UNLOADER FOR LOOSE MATERIALS

SL
SF



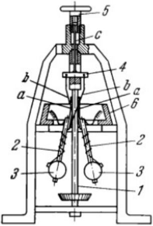
Unloader *1* has two compartments separated by partition *a*. Each compartment is alternately loaded with material from bunker *2* and is automatically unloaded when the unloader turns about fixed axis *A*. One extreme position of the unloader is shown by continuous lines and the other by dot-and-dash lines.

9. GOVERNOR MECHANISMS (430 through 440)

430 LEVER-TYPE CENTRIFUGAL GOVERNOR

SL

G

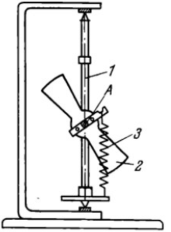


Secured to spindle *1* by flat springs *a* are rods *2* along which balls *3* slide. The balls are suspended by coiled wires *b* from member *4* which can be lowered and raised in a slot in the thicker part of spindle *1*. Member *4* is connected to tie-rod *c* which passes through the central hole in spindle *1* and is secured in the hole of regulating screw *5*. Rods *2* mount brushes which, when forced against conical surface *6*, have a braking effect.

431 LEVER-TYPE CENTRIFUGAL GOVERNOR

SL

G

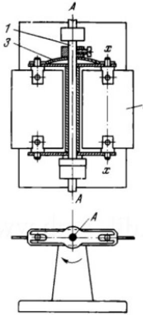


Vanes *2*, turning about horizontal axis *A* secured on vertical shaft *1*, turn by the action of centrifugal force, overcoming the resistance of spring *3*. In rotation of shaft *1*, vanes *2* are subject to air resistance which increases with the speed of rotation of shaft *1*.

432

VANE-TYPE GOVERNOR WITH VARIABLE BRAKING FORCE

SL
G

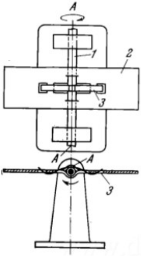


In rotation of shaft *1* of the governor about fixed axis *A*, vanes *2*, linked to the shaft through a friction coupling with bent spring *3*, are subject to air resistance. The braking force due to this air resistance can be regulated by turning vanes *2* about axis *x-x* and clamping them.

433 VANE-TYPE GOVERNOR

SL

G



In rotation of shaft *1* of the governor about fixed axis *A*, vane *2* is subject to air resistance which has a braking effect. Rotation is transmitted from shaft *1* to vane *2* by flat spring *3*, inserted into openings in the vane.

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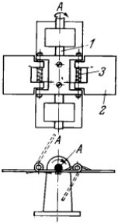
434 VANE-TYPE GOVERNOR WITH AUTOMATIC SETTING OF THE VANES

SL

G

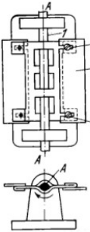


In rotation of shaft *1* about fixed axis *A*, vanes *2* are swivelled by air resistance about their pins. This varies the resistance to rotation of shaft *1*. The vanes are returned to their initial position by springs *3*.

435

VANE-TYPE GOVERNOR WITH VARIABLE BRAKING FORCE

SL
G



In rotation of shaft *1*, on which vanes *2* are attached, about fixed axis *A*, a braking effect is produced by air resistance. The braking force can be regulated by adjusting the vanes, which have corresponding slots *a*, and securing them with screws *b*.

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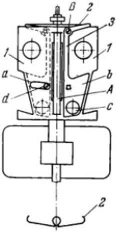
436

VANE-TYPE GOVERNOR FOR CLOCK CHIMES

SL
G

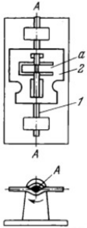


Vanes *1* and spring *2* are linked to shaft *A* whose speed is to be governed. Vanes *1* have pivots *B* on which levers *3* with blades *b* and weights *c* turn. The swinging motion of levers *3* is limited by pins *d* sliding in slots *a* of vanes *1*. When the speed of the shaft increases, weights *c* are forced outward, turning levers *3* about pivots *B*. This increases the moment of the resistance of the air to rotation, thereby governing the angular velocity of shaft *A*.

437

VANE-TYPE GOVERNOR WITH AN ELASTIC LUG

SL
G



In rotation of shaft *1* of the governor about fixed axis *A* together with vane *2*, secured on the shaft, a braking effect is produced by air resistance. Vane *2* has a U-shaped slot designed so that lug *a* can act as a spring.

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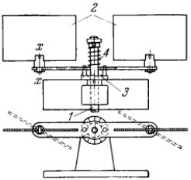
438

VANE-TYPE GOVERNOR WITH VARIABLE BRAKING FORCE

SL
G



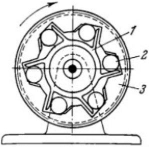
In rotation of shaft *1* and vanes *2*, linked to the shaft by means of toothed clutch *3* and coil spring *4*, a braking effect is produced by air resistance. The braking force can be regulated by turning vanes *2* about the *x-x* axis and clamping them.

439

BALL-TYPE GOVERNOR FOR THE IGNITION ADVANCE ANGLE OF AN ENGINE

SL

G



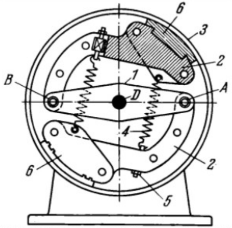
Upon an increase in the speed of the engine shaft, the speed of governor body *1*, rigidly mounted on the shaft, also increases. Ball weights *2* are arranged in the recesses of body *1* and inner slots of gear *3*. When the speed of body *1* is increased, weights *2* are forced outward, turning gear *3* and thereby increasing the ignition advance angle.

440

TYPEWRITER GOVERNOR

SL

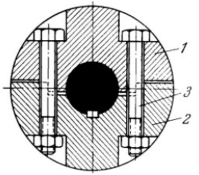
G



Lever *1*, turning about fixed axis *D*, is connected by turning pairs *A* and *B* to levers *2*. In rotation of lever *1*, levers *2* with weights are turned outward by centrifugal force about pins *A* and *B*, pressing shoes *6* to fixed cylinder *3* by overcoming the resistance of springs *4*. This produces the braking effect. Screws *5* serve to adjust the tension of springs *4*.

10. CLUTCH AND COUPLING MECHANISMS
(441 through 459)

441	**CLAMP COUPLING**	SL C



This permanent coupling consists of two halves, *1* and *2*, held rigidly together by bolts *3*.

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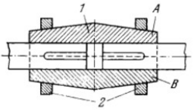
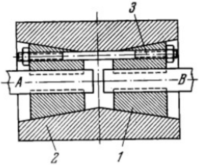
442	**CONE-RING COUPLING**	SL C



Permanent coupling *1* consists of two halves, *A* and *B*. Rings *2*, driven up on the tapers of the coupling, hold it tightly on the shafts being joined.

443 CONE-WEDGE COUPLING

SL
C



This permanent coupling consists of sleeve *2*, bored tapering from each end towards the middle, so that cone-shaped split wedges *1* can be inserted and drawn together by studs *3*, thus pressing wedges *1* against shafts *A* and *B*.

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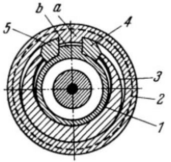
444 FLEXIBLE COUPLING

SL
C



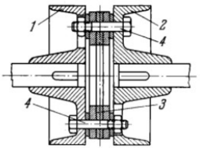
This permanent coupling consists of concentric cylinders *1* and *2*, having longitudinal splines *a* and *b*, clamped between two strips *4* and *5* which are drawn together by horseshoe-type spring *3*.

445

FLEXIBLE COUPLING WITH ELASTIC WASHERS

SL

C



This permanent coupling consists of two disks, *1* and *2*, drawn together by bolts *4*. Flexibility is achieved by inserting elastic washers *3* between the disks.

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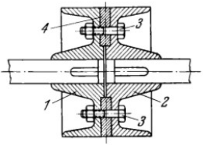
446

FLANGE COUPLING WITH AN ALIGNING RING

SL

C

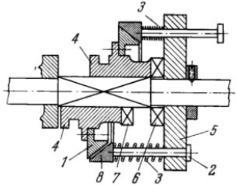


This permanent coupling consists of two flanges, *1* and *2*, keyed on the shafts being joined and drawn together by bolts *3*. Aligning ring *4* is provided.

447

POSITIVE CLUTCH WITH A CONICAL SYNCHRONIZER

SL
C

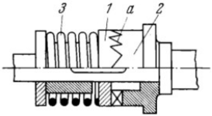


At the beginning of engagement (lower half of the drawing), sleeve *4* is shifted to the right so that cone *1* contacts cone *8* which is secured on rods *2* sliding in holes of driven disk *5*. After equalizing the speeds of the driving and driven cones, *1* and *8*, further movement of sleeve *4* engages clutch jaws, *6* and *7* (upper half of the drawing). Springs *3* hold the cones in contact.

448

SAFETY TOOTHED CLUTCH

SL
C

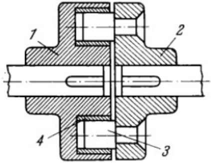


When the transmitted torque exceeds the permissible value, the resistance of spring *3* is overcome and teeth *a* of clutch members *1* and *2* are disengaged so that the driven member begins to slip.

449 PIN-TYPE FLEXIBLE COUPLING

SL

C



This permanent coupling consists of two flanges, *1* and *2*. Pins *3*, press-fitted in flange *2*, enter leather bushings *4* in the holes of flange *1*.

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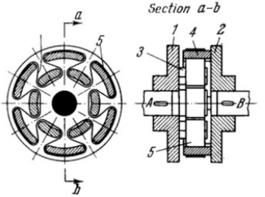
450 ENDLESS BELT FLEXIBLE COUPLING

SL

C



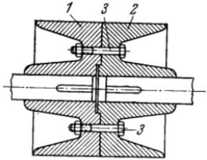
Flanges *1* and *2* of this permanent coupling have shaped lugs *3* and *4*. Endless leather belt *5* is interwoven between lugs *3* and *4*, providing flexibility in the drive between shafts *A* and *B*.

451

FLANGE COUPLING WITH AN ALIGNING SHOULDER

SL

C



This permanent coupling consists of two flanges, *1* and *2*, keyed on the shafts being joined and drawn together by bolts *3*. An aligning shoulder and recess are provided.

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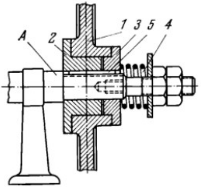
452

SAFETY FRICTION CLUTCH

SL

C



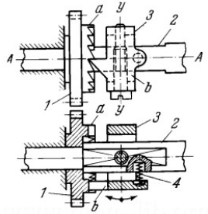
Flangers *2* and *3* of the clutch are keyed on shaft *A* by means of key *5*. The hub of driven pulley *1* is clamped between flanges *2* and *3* by spring *4*. When the transmitted torque exceeds the permissible value, pulley *1* begins to slip with respect to flanges *2* and *3*.

453

RATCHET CLUTCH WITH FACE ENGAGEMENT

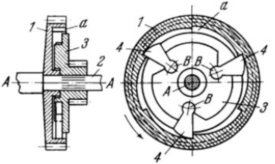
SL

C



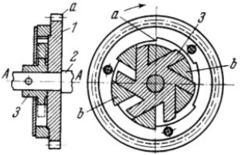
Member *1*, rotating freely about fixed axis *A* of shaft *2* has a face-type ratchet wheel with teeth *a*. Rigidly mounted on shaft *2* is member *3* which turns about axis *y-y*. Pawl *b* of member *3* engages face teeth *a* and member *1* rotates together with shaft *2*. Member *3* is actuated by spring *4*. Upon reversal of the rotation of shaft *2*, pawl *b* slides along the inclined surfaces of teeth *a* and member *1* stops rotating.

454	RATCHET CLUTCH WITH INTERNAL ENGAGEMENT	SL C



Member *1*, rotating freely about fixed axis *A* of shaft *2*, has ratchet teeth *a* on its inner surface. Rigidly mounted on shaft *2* is member *5* having three pawls *4* turning about axes *B*. Upon counterclockwise rotation of shaft *2*, member *1* rotates together with member *3*. Upon reversal of shaft *2*, member *1* stops rotating.

455	RATCHET CLUTCH WITH INTERNAL ENGAGEMENT	SL C



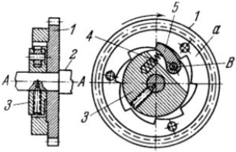
Member *1*, rotating freely about fixed axis *A* of shaft *2*, is rigidly secured to internal ratchet wheel *a*. Rigidly mounted on shaft *2* is member *3* having angular recesses in which triangular members *b* slide. Upon clockwise rotation of member *1*, members *b* are wedged between the teeth of ratchet wheel *a* and the angular recesses of member *3*. At this member *3* rotates together with member *1*.

456

RATCHET CLUTCH WITH INTERNAL ENGAGEMENT

SL

C



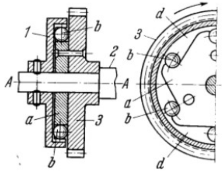
Member *1*, rotating freely about fixed axis *A* of shaft *2*, is rigidly secured to internal ratchet wheel *a*. Rigidly mounted on shaft *2* is member *3* having pawl *5* which turns about axis *B*. Pawl *5* is actuated by spring *4*. Upon clockwise rotation of member *1*, member *3* and shaft *2* rotate together with member *1*. Upon reversal of rotation, members *1* and *3* are disengaged.

457

BALL-TYPE OVERRUNNING CLUTCH

SL

C

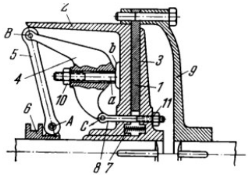


Member *1*, rigidly mounted on shaft *2*, rotates about fixed axis *A*. Member *3* with sprocket *a* rotates freely on shaft *2*. Balls *b* become wedged in the narrowing space *d*, engaging members *1* and *3* which rotate together with shaft *2*. Members *1* and *3* are disengaged when the direction of rotation is reversed.

458

LEVER-TYPE FRICTION CLUTCH

SL
C

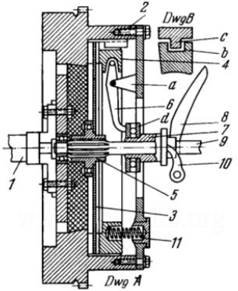


Lever *5* is connected by turning pair *A* to collar *6* which slides axially along one of the shafts joined by the clutch. Lever *4* is connected by turning pairs *B* and *C* to lever *5* and eyebolt *8*. Eyebolt *8* passes through the hole in flanges *2* and *3* with a certain clearance. Lever *4* has projection *a* which slides along boss *b* of flange *2*. When collar *6* is shifted to the left, flanges *2* and *3* are drawn together and they clamp disk *1* which is secured rigidly to flange *9*. Springs *7* disengage the clutch when collar *6* is shifted to the right. The clutch is adjusted by regulating nuts *10* and *11*.

459

LEVER-TYPE FRICTION CLUTCH

SL
C

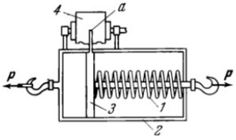


Driven friction disk *3* (dwg *A*) is rigidly mounted on sleeve *5* which slides freely along splines of shaft *9* of the transmission gearbox. Inside flywheel *2* is friction ring *4* which has slots *b* on its circumference. Projections *c* of flywheel *2* fit into slots *b* (dwg *B*). Due to the slots and projections, ring *4* always rotates together with flywheel *2* but can slide along its axis. Motion is transmitted from crankshaft *1* of the engine through flywheel *2*, ring *4*, driven disk *3* and sleeve *5* to shaft *9* of the transmission gearbox. The clutch is disengaged by a special lever mechanism. Levers *6*, pivoted on brackets *a* of flywheel *2*, have one end which enters a corresponding recess in ring *4*. When clutch pedal *8* is depressed it turns shifting lever *10* of clutch sleeve *7* to the left. This also shifts ball thrust bearing *d* which bears against the other end of levers *6*. Turning, levers *6* shift ring *4* to the right, withdrawing it from driven disk *3*. The clutch is engaged by releasing pedal *8* from the action of springs *11* which squeeze disk *3* between ring *4* and flywheel *2*.

11. MECHANISMS OF MEASURING AND TESTING DEVICES (460 through 478)

460 TENSILE SPRING DYNAMOGRAPH

SL
M



Pulling force *P* acts on helical measuring spring *1*, arranged between frame *2* of the instrument and movable thrust washer *3*. The deflection of the measuring spring is recorded by pencil *a* on moving paper chart *4*.

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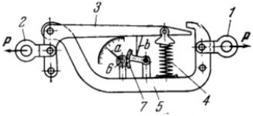
461 TENSILE LEVER-TYPE DYNAMOMETER

SL
M

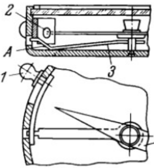


Pulling force *P*, applied to shackles *1* and *2*, is transmitted through two-arm lever *3* to measuring spring *4* whose other end bears against frame *5* of the instrument. Through lug *b*, lever *3* turns segment gear *7* and gear *6* which has hand *a* that indicates the magnitude of pulling force *P*.

462

LEVER MECHANISM FOR ARRESTING A COMPASS NEEDLE

SL
M



When curved member *2* is shifted by pushing knob *1* counterclockwise, a bevel on member *2* forces down bent end *A* of lever *3*. This turns lever *3*, and its other end presses needle *4* against the glass of the compass.

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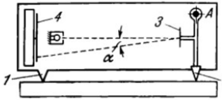
463

RECORDING STRAIN GAUGE WITH OPTICAL MAGNIFICATION

SL
M

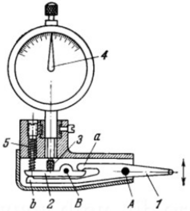


Knife edge *2* turns about fixed axis *A*. The change in the distance between knife edges *1* and *2* upon strain of the test piece causes mirror *3* and the light beam it reflects to turn through a certain angle α. The deflection of the reflected beam is photorecorded on photographic film *4* moving perpendicular to the plane of the drawing.

464

LEVER-TYPE MEASURING HEAD

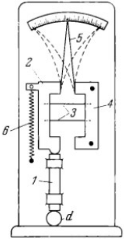
SL
M



The measuring force turns lever *1* about fixed axis *A* and its arms *a* and *b* bear against lever *2*, turning it about axis *B*. The motion of lever *2*, in contact with spindle *3* of the dial indicator, is transmitted to hand *4*. Spring *5* returns lever *2* to its initial position.

465 REED-TYPE MECHANICAL COMPARATOR

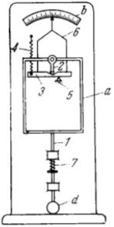
SL
M



Upon displacement of measuring spindle *1*, movable block *2*, floating on flat steel reeds *3* connected to fixed block *4*, hand *5* is deflected to either side. Hand *5* consists of two flat steel reeds. Spring *6* holds movable block *2* and measuring spindle *1* against workpiece *d* being measured.

466 LEVER-TYPE MECHANICAL COMPARATOR

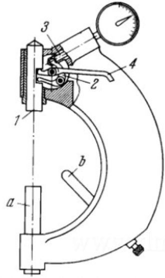
SL
M



When measuring spindle *1* is raised, frame *a*, rigidly secured to the spindle, and knife edge *2* are also raised. This enables spring *4* to turn member *3* on fixed knife edge *5*. The deflection of member *3* from its horizontal position is indicated by hand *6* on scale *b*. Spring *7* holds measuring spindle *1* constantly against workpiece *d* being measured.

467 LEVER-TYPE DIAL INDICATOR SNAP GAUGE FOR SHAFT DIAMETER MEASUREMENT

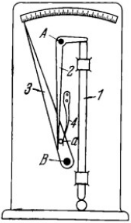
SL
M



The deviation of the shaft diameter from the required value is transmitted through measuring anvil *1* and lever *2* to spindle *3* of the dial indicator. The measuring anvil is retracted by lever *4*. Adjustable anvil *a* and backstop *b* are set before measurement to the required diameter of the shaft and are firmly clamped.

468 LEVER-TYPE MECHANICAL COMPARATOR

SL
M

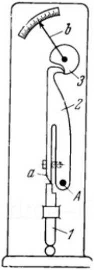


Upon upward displacement of measuring spindle *1*, lever *2* turns about axis *A* and its long arm presses pin *a* of hand *3* which is consequently turned about axis *B*. Spring *4* returns hand *3* to its initial position.

469

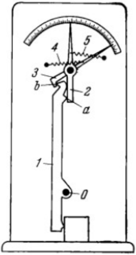
LEVER-TYPE MECHANICAL COMPARATOR

SL
M



Upon upward displacement of measuring spindle *1*, it bears against knife edge *a* of lever *2*, turning the lever about fixed axis *A*. Lever *2* turns cam *3* with hand *b*.

470 LEVER-TYPE MECHANICAL COMPARATOR SL M

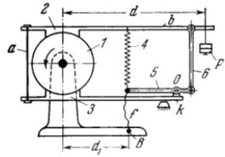


In making a measurement, measuring lever *1* turns about fixed axis *O* and its lugs *a* and *b* actuate hands *2* and *3*, turning them through different angles. Springs *4* and *5* hold hands *3* and *2* in contact with lugs *b* and *a* of measuring lever *1*.

471

LEVER-TYPE BRAKE DYNAMOMETER

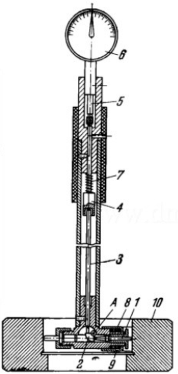
SL
M

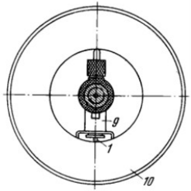


To find the braking torque, pulley *1* is mounted on the engine or motor shaft. Shoes *2* and *3* are held against pulley *1* by means of tie-rod *a* and spring *4*. If spring *4* is tensioned so that pulley *1* tends to rotate the whole system, then cord *f* is pulled taut and it turns lever *5* about axis *O*. At this, link *6* spreads levers *b* and *k* of shoes *2* and *3*. This reduces the frictional force moment which becomes equal to $M = Pd + Td_1$, where T is the tension of the cord. By regulating spring *4*, tension T should be reduced to a minimum and point *B* located as close as possible to the axis of the brake pulley. Under these conditions, the quantity Td_1 can be neglected and the braking torque can be taken equal to $M = Pd$.

472 LEVER-TYPE BORE GAUGE

SL
M





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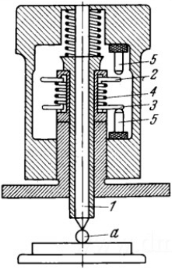
Upon a deviation of the bore diameter being measured from the required value, sensitive contact *1* is displaced and it actuates lever *2* which turns about fixed axis *A*. Through rods *3* and *4*, the motion of lever *2* is transmitted to measuring spindle *5* of dial indicator *6*. Spring *7* maintains constant contact between members *1*, *2*, *3*, *4* and *5*. Spring *8* holds locating fork *9* against the bore. Bore diameters are checked by comparison with the hole of standard ring *10*.

473 ELECTRIC-CONTACT GAUGE MECHANISM

SL

M

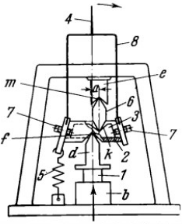


Mounted on sensitive spindle *1*, which bears against workpiece *a* being checked, are two disks, *2* and *3*, held by spring *4* to the locating flanges of spindle *1*. Upon displacement of spindle *1* disks *2* and *3* make contact with either of contact pins *5*: with the top contact pin for oversize workpieces *a*, with the bottom pin for undersize workpieces and with neither for within-size workpieces.

474 LEVER-TYPE MECHANISM OF A MECHANICAL COMPARATOR

SL

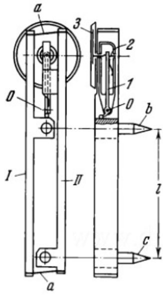
M



Member *1*, sliding in stationary guide *b*, has head *d* whose knife edge enters V-slot *f* of member *2*. Member *3*, with V-slot *k*, has frame *8* ending in hand *4*. Rocking prism *6* has knife edges at each end which enter V-slots *k* and *m* of frame member 3 and stationary head *e*. Straight-line motion of member *1* is transmitted through members *2* and *3* to hand *4*. Spring *5* holds members *1* and *2* in constant contact. Frame member *3* can be adjusted with respect to member *2* by screws *7* to change distance *a* between member *1* and head *e*.

475 LEVER-TYPE STRAIN GAUGE

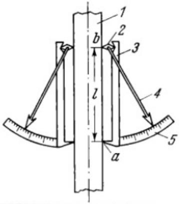
SL
M



This strain gauge consists of two parts, *I* and *II*, connected together by thin flat steel reeds *a*. Parts *I* and *II* have points *b* and *c* whose centre-to-centre distance *l* is the length being measured on the piece being tested. Upon a change in length of the test piece, lever *1*, turning about pin *O* (rigidly secured in part *II* of the strain gauge), turns screw device *2* about its axis, thereby turning hand *3*.

476 LEVER-TYPE STRAIN GAUGE

SL
M

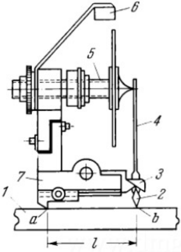


Member *3* ends in sharp point *a*. Rocking prism *2* ends in sharp point *b*. The distance *l* between points *a* and *b* is the length being measured on piece *1* being tested. Upon a change in length *l*, prism *2*, turning on its knife edge with respect to member *3* moves hand *4*, secured in the centre of prism *2*, thereby indicating the amount of strain on scale *5*.

477

AISTOV LEVER-TYPE STRAIN GAUGE

SL
M

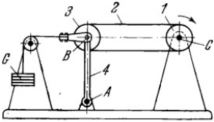


Member *7* has sharp point *a*. Rocking prism *2* ends in sharp point *b*. The distance *l* between points *a* and *b* is the length being measured on piece *1* being tested. Upon a change in length *l* of test piece *1*, prism *2*, turning with respect to member *3*, moves lever *4* which is linked to prism *2*. By adjustment with screw *5*, the point of the dial is brought into contact with lever *4*. The reading is made on the dial by means of index *6*.

478

LEVER-TYPE DEVICE FOR TESTING BELTS

SL
M



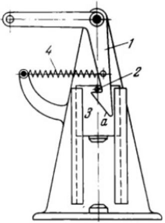
Lever *4* turns about fixed axis *A* and is connected by turning pair *B* to pulley *3* over which belt *2* runs. The belt also runs over pulley *1* which rotates about fixed axis *C*. Load is applied to the belt by weight *G*. Upon rotation of pulley *1*, belt *2* is subject to a tensile load.

12. HAMMER, PRESS AND DIE MECHANISMS
(479 through 483)

479

STARTING LEVER OF A DROP HAMMER

SL
HP



When lever *1* is turned with its latch, pin *2* is freed and head *3* drops. Spring *4* returns lever *1* to its initial position. Bevelled surface *a* of lever *1* enables the lever to catch pin *2* when head *3* is lifted.

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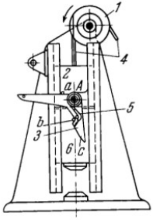
480

STARTING LEVER OF A DROP HAMMER

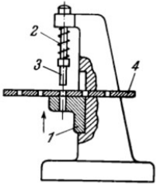
SL
HP



Striker *2*, suspended on wire rope *4* running over pulley *1*, slides downward in guides and its pin *a* strikes two-armed lever *3*. This lever turns about fixed axis *A*, frees pin *b* and head *6* drops. Flat spring *5* returns lever *3* to its initial position. Bevelled surface *c* of lever *3* enables the lever to catch pin *b* when head *6* is raised.

481 SLIDE OF A HOLE PUNCHING PRESS

SL
HP



Upon motion of member *1* upward, and with sufficient tension of spring *2*, punch *3* will punch a hole in material *4*.

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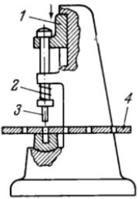
482 SLIDE OF A HOLE PUNCHING PRESS

SL
HP

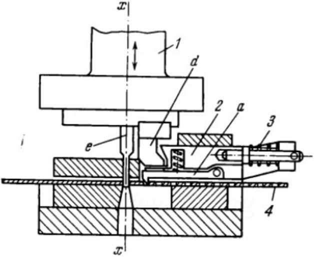


Upon motion of member *1* downward, punch *3*, actuated by spring *2*, will punch a hole in material *4*.

483

WEDGE-TYPE DIE FEED MECHANISM

SL
HP

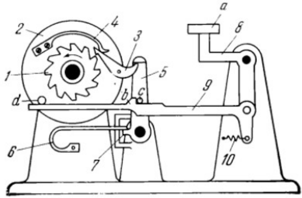


Wedge cam *d* is secured rigidly to upper die *1* which reciprocates vertically along axis *x-x*. Punch *e* punches a hole in strip material *4*. In upward motion of wedge cam *d*, sliding member *2* moves to the right and hook *a*, connected to member *2*, pulls strip *4* to the next position. In downward motion of upper die *1*, sliding member *2* returns to its initial position due to the action of spring *3*, and hook *a*, due to its bevel, is raised above strip *4*.

13. KEY MECHANISMS (484 through 487)

484 LEVER-AND-RATCHET-TYPE KEY MECHANISM

SL
K



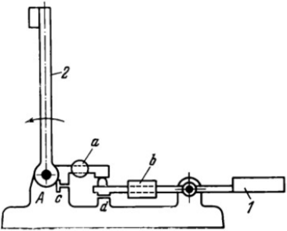
Continuously rotating ratchet wheel *1* has a common axis with driven disk *2*. Pawl *3*, pivoted on disk *2*, is actuated by spring *4*. Engagement of pawl *3* and ratchet wheel *1* is prevented by stop lever *5*, held by spring *6* against stop *7*. When key *a* of two-armed lever *8* is depressed, starting rod *9*, hinged to lever *8*, is moved to the right. Shoulder *b* of rod *9* turns lever *5* to free pawl *3* which engages ratchet wheel *1*. At this, disk *2* begins to rotate. Pin *d*, pressing downward on the left end of rod *9*, disengages it from lever *5* which returns to its initial position and catches pawl *3* after one revolution of disk *2*. When key *a* is released, rod *9* is returned by spring *10* to its horizontal position and moves to the left so that shoulder *b*, which was to the right of pin *c*, returns to the position shown in the drawing.

485

LEVER-TYPE KEY MECHANISM

SL

K



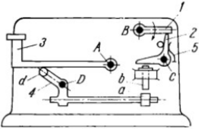
When key *1* is depressed, lever *2* turns about fixed axis *A*. Weights *a* and *b* return lever *2* and key *1* to their initial position when key *1* is released. The motions of key *1* and lever *2* are limited by stops *c* and *d*.

486

INTERMITTENT-ACTION LEVER-TYPE KEY MECHANISM

SL

K



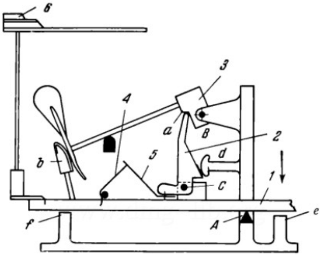
Lever *1* turns about fixed axis *B*. Two-armed pawl *2* turns about fixed axis *C* and one of its ends slides along lever *1*. Lever *4* turns about fixed axis *D* and has rigidly secured hammer *a*. Pin *d* of lever *4* slides along key *3* which turns about fixed axis *A*. Lever *1*, subject to a constant torque, is held against rotation by pawl *2*. When key *3* is depressed, lever *4* is turned and hammer *a* strikes rod *b* which, in turn, turns pawl *2*, freeing lever *1*. Spring *5* applies force to hold pawl *2* against lever *1*.

487

LEVER-TYPE MECHANISM OF A GRAND PIANO KEY

SL

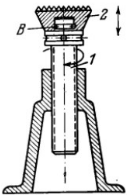
K



Key *1* turns about knife edge *A*. Felt-covered hammer *3* turns about fixed axis *B*. When key *1* is pressed, member *2*, turning about fixed axis *C*, acts with its end on shoulder *a* of hammer *3* which strikes the corresponding string. At the moment of the blow, key *1* runs against stop *e* and the left end of the key raises damper *6* from the strings. Damper *6* rests freely on key *1*. After striking the string, hammer *3*, dropping back, meets stop *b* with its shank. The hammer rests on stop *b* the whole time the key is depressed. Stop *d* keeps member *2* in engagement with shoulder *a* of hammer *3*. By means of tie-rod *5*, connected to member *2*, spring *4* tends to press member *2* against shoulder *a* of hammer *3*. When the key is released, it drops back and rests freely on stop *f*. Members *2*, *4* and *5* and stop *b* are all mounted on the key.

14. MECHANISMS OF MATERIALS HANDLING EQUIPMENT (488 through 492)

488 SCREW JACK SL MH



Screw *1* is connected by a screw pair to the fixed base, and by turning pair *B* to bearing plate *2*. When screw *1* is turned by a bar inserted in a hole in the screw head, the load, resting on bearing plate *2*, is either raised or lowered.

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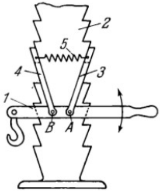
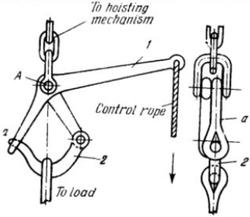
489 RACK-AND-LEVER JACK SL MH



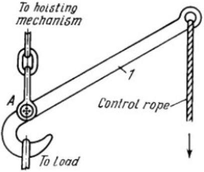
Levers *1*, located in front and in back of ratchet-type rack *2*, are hinged to pairs of pawls, *3* and *4*. Each pair of pawls is connected by a strip perpendicular to the plane of the drawing. When levers *1* are oscillated, the levers, with the load suspended from the hook, climb upward by means of pawls *3* and *4* whose strips engage the teeth of rack *2*. Springs *5* hold the pairs of pawls, *3* and *4*, against rack *2*.

490 LEVER-TYPE RELEASING HOOK SL MH


To hoisting mechanism
1
A
Control rope
a
2
To load
a
2

In lifting the load, latch *a*, rigidly mounted on lever *1*, holds hook *2* in its operative position. When the load has been lifted to the required height, the control rope is pulled. This turns lever *1* about axis *A*. Latch *a* is disengaged from hook *2*, releasing the load.

491 LEVER-TYPE RELEASING HOOK SL MH

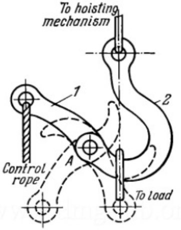

To hoisting mechanism
1
A
Control rope
To load

After lifting the load to the required height, the control rope is pulled. This turns lever *1* about axis *A*, thereby releasing the load.

492

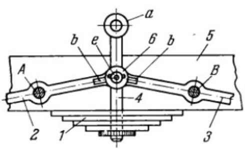
LEVER-TYPE RELEASING HOOK

SL
MH


To hoisting mechanism
1
2
Control rope
A
To load

After lifting the load to the required height, the control rope is pulled. This turns lever *1* about axis *A* and throws the load off hook *2*. Dash lines show three consecutive positions of lever *1*.

493	LEVER-TYPE SAFETY DEVICE FOR A LIFT	SL S



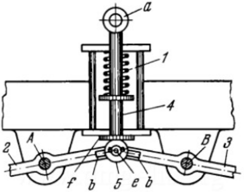
Levers *2* and *3*, turning about fixed axes *A* and *B*, have slots ***b*** into which pin *e* of member *6* enters. The lift cage is suspended from the wire rope on eye *a* of tie-rod *4*. During normal operation of the lift, leaf spring *1* is held tightly against frame *5*. If the rope breaks, spring *1* is released, pulling tie-rod *4* with eye ***a*** downward, and pin *e* of member *6*, sliding along slots ***b*** of levers *2* and *3*, turns these levers about axes *A* and *B*. This engages the interlocking device which stops the lift cage and keeps it from dropping.

494

LEVER-TYPE SAFETY DEVICE FOR A LIFT

SL

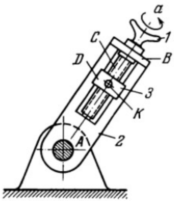
S



Levers *2* and *3*, turning about fixed axes *A* and *B*, have slots *b* into which pin *e* of member *5* enters. The lift cage is suspended from the wire rope on eye *a* of tie-rod *4*. Spring *1* is compressed. If the rope breaks, the spring is released, head *f* of tie-rod *4* pushes down member *5* and levers *2* and *3*, turning about axes *A* and *B*, engage the interlocking device which stops the lift cage and keeps it from dropping.

16. LINK-LENGTH ADJUSTMENT MECHANISMS
(495 through 502)

495	**VARIABLE-RADIUS CRANK**	**SL** **LL**



Member *1* is connected by turning pair *B* to crank *2* and by screw pair *C* to member *3* which is connected by sliding pair *D* to crank *2*. Length (throw) $\overline{AK}$ of crank *2* can be changed by adjusting member *3* along axis *Aa*. This is accomplished by turning member *1* about axis *Aa*.

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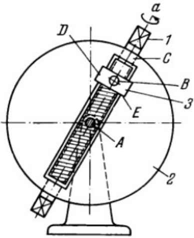
496	**VARIABLE-RADIUS CRANK**	**SL** **LL**



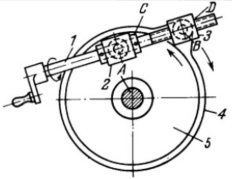
Screw *1* is connected by turning pair *C* to crank *2* and by screw pair *D* to member *3* which is connected by sliding pair *E* to crank *2*. Length (throw) $\overline{AB}$ of crank *2* is changed by adjusting member *3* along axis *Aa*. This is accomplished by turning screw *1* about axis *Aa*. Point *B* of the crankpin can be adjusted to either side of point *A*.

497

LEVER-TYPE SCREW MECHANISM FOR A CRANK WITH A VARIABLE SETTING ANGLE

SL

LL



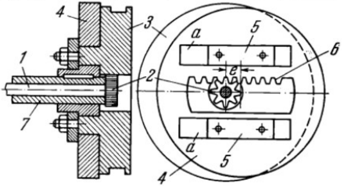
Screw *1* is connected by turning pair *C* to member *2*, which turns about axis *A* of disk *5*, and by screw pair *D* to member *3*, which turns about axis *B* on the projection of the sleeve of member *4*. When screw *1* is turned, member *3* is moved along the axis of screw pair *D* and the sleeve of member *4* is turned with respect to disk *5*. This changes the setting angle of member *4* with respect to disk *5*.

498

ECCENTRIC CAM WITH VARIABLE ECCENTRICITY

SL

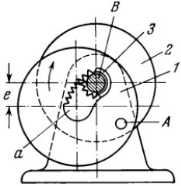
LL



Disk *4* of a circular eccentric cam carries two rectangular lugs *5* and has gear rack *6*. Disk *3* has guides *a* along which lugs *5* slide. Shaft *1*, with pinion *2* at its end, passes through hollow shaft *7*. When shaft *1* is turned, pinion *2*, meshing with rack *6* on disk *4* of the eccentric cam, moves the cam along guides *a* and thereby changes the eccentricity *e*.

499 ECCENTRIC CAM WITH VARIABLE ECCENTRICITY

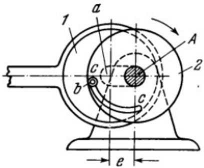
SL
LL



Eccentric cam *1* and disk *2* are pivoted at point *A*. Disk *1* has slot *a* with internal teeth which mesh with segment pinion *3*. The eccentricity *e* of eccentric cam *1* can be changed by turning pinion *3* about axis *B*.

500 ECCENTRIC CAM WITH VARIABLE ECCENTRICITY

SL
LL

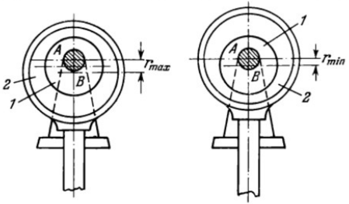


The eccentricity *e* of eccentric cam *1* can be changed by turning cam *1* with respect to disk *2* so that slot *a* of the cam slides along shaft *A* and bolt *b* along spiral slot *c-c* of disk *2*. Then bolt *b* is tightened to secure the adjustment.

501

ECCENTRIC CRANK OF VARIABLE RADIUS

SL
LL



By turning and clamping eccentric cam *1* in disk *2* it is possible to vary length (throw) $\overline{AB}$ of the crank from $r_{\max}$ to $r_{\min}$.

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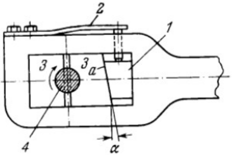
502

WEDGE-TYPE COMPENSATOR

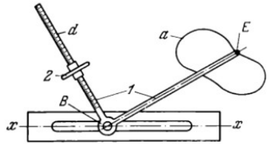
SL
LL



Shaft *4* runs in bearing inserts *3*. The right-hand insert has bevel *a* along which wedge block *1* slides with its bevel. Wedge block *1* is held in contact with right-hand insert *3* by means of flat spring *2*. Wear of inserts *3* is compensated by the lowering of wedge block *1* due to the action of spring *2*. Wedge block *1* cannot rise by itself since angle α is less than the angle of friction.

17. MECHANISMS FOR MATHEMATICAL OPERATIONS
(503 through 506)

503	LEVER-TYPE PLANIMETER	SL MO



In running tracing point E around the perimeter of figure a, point B of arms 1 slides along axis x-x and wheel 2 slides along graduated arm d. The area limited by the closed curve is determined by the formula $A = cb$, where $c = \overline{EB}$ and b is the displacement of wheel 2 along arm d.

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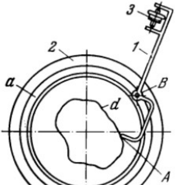
504	LEVER-TYPE PLANIMETER	SL MO

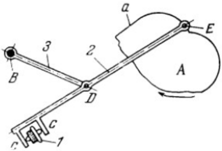


To find the area within a figure, tracing point A is run around its perimeter. Point A is connected to lever 1 whose point B slides around annular guide a in body 2 of the planimeter. The number of revolutions of recording wheel 3 is proportional to the area being measured.

505

LEVER-TYPE PLANIMETER

SL
MO



Arm *3* turns about fixed point B and is connected by turning pair D to arm *2* which has recording wheel *1* turning about axis *c-c*. When tracing point E is moved around the perimeter of closed curve **a**, the angle of revolution of recording wheel *1* is proportional to area A within closed curve **a**:

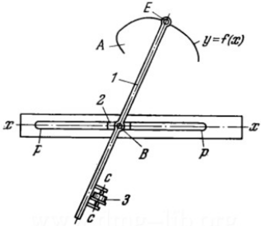
$$A = k\,(b_1 - b_0)$$

$$k = lr$$

where b_0 = initial reading on the wheel in beginning to trace the figure
b_1 = final reading when the figure has been traced
k = proportionality factor
l = length of tracing arm *2* from tracing point E to pivot point D
r = radius of the recording wheel.

506 LEVER-TYPE INTEGRATOR

SL
MO



Slide block 2 slides along stationary guide p-p and is connected by turning pair B to arm 1 which mounts recording wheel 3 turning about axis c-c. When tracing point E is moved along curve $y = f(x)$, arm 1 turns about point B and simultaneously slides by means of slide block 2 along axis x-x. Angle φ of rotation of recording wheel 3 is proportional to the integral of the curve:

$$\varphi = k \int_{x_1}^{x_2} f(x)\,dx$$

If tracing point E is run around the perimeter of closed curve $y = f(x)$, angle φ_1 of revolution of the recording wheel is proportional to the difference in the integrals of the upper and lower branches of the curve:

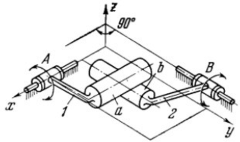
$$\varphi_1 = k \int_{x_1}^{x_2} f'(x)\,dx - \int_{x_2}^{x_1} f''(x)\,dx = \frac{1}{rl} A = RA$$

where R = proportionality factor, equal to $1/rl$
r = radius of the recording wheel
l = length of tracing arm 1 from tracing point E to turning point B
A = area within the closed curve.

18. CONTACTING LEVER MECHANISMS
(507 through 523)

507 CONTACTING LEVER MECHANISM WITH CONTACTING ROUND CYLINDERS

SL
CL



Links *1* and *2*, connected by turning pairs *A* and *B* to the base, contact each other through round cylinders *a* and *b*. The axis of cylinder *a* of link *1* is parallel to the axis of turning pair *A*. The axis of cylinder *b* of link *2* is parallel to the axis of turning pair *B*.

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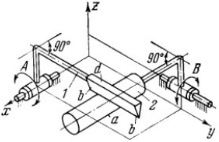
508 CONTACTING LEVER MECHANISM WITH CONTACTING ROUND CYLINDER AND PRISM

SL
CL



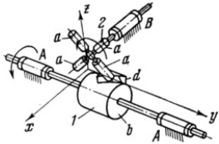
Links *1* and *2* are connected by turning pairs *A* and *B* to the base, and their turning axes are perpendicular but do not intersect. Links *1* and *2* contact each other through round cylinder *a* and edge *b-b* of triangular prism *d*. The axis of cylinder *a* is perpendicular to but does not intersect the turning axis of link *2*. Straight line *b-b* of the prism is perpendicular to but does not intersect the turning axis of link *1*.

509

CONTACTING LEVER MECHANISM WITH CONTACTING ROUND CYLINDER AND HELICAL SURFACE

SL

CL



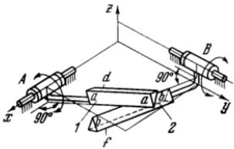
Links *1* and *2* are connected by turning pairs *A* and *B* to the base, and their turning axes are perpendicular but do not intersect. Links *1* and *2* contact each other through round cylinders *a* and helical surface *d* cut into cylinder *b*. The axes of cylinders *a* are perpendicular to and intersect the turning axis of link *2*. The axis of cylinder *b*, on which helical surface *d* is cut, coincides with the turning axis of link *1*.

510

CONTACTING LEVER MECHANISM WITH CONTACTING PRISMS

SL

CL



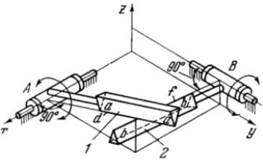
Links *1* and *2* are connected by turning pairs *A* and *B* to the base, and their turning axes are perpendicular but do not intersect. Links *1* and *2* contact each other through edges *a-a* and *b-b* of triangular prisms *d* and *f*. These edges are perpendicular to but do not intersect the axes of turning pairs *A* and *B*.

511

CONTACTING LEVER MECHANISM WITH CONTACTING PRISMS

SL

CL



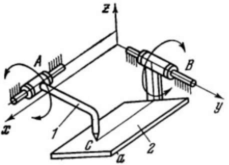
Links *1* and *2* are connected by turning pairs *A* and *B* to the base, and their turning axes are perpendicular but do not intersect. Links *1* and *2* contact each other through edges *a-a* and *b-b* of triangular prisms *d* and *f*. These edges are perpendicular to and intersect the axes of turning pairs *A* and *B*.

512

CONTACTING LEVER MECHANISM WITH CONTACTING PLANE AND POINT

SL

CL



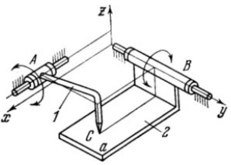
Links *1* and *2* are connected by turning pairs *A* and *B* to the base, and their turning axes are perpendicular but do not intersect. Links *1* and *2* contact each other through point *C* and plane *a* which intersects the axis of turning pair *B*. Point *C* of contact of link *1* with link *2* is located at a constant distance from the turning axis of link *1*.

513

CONTACTING LEVER MECHANISM WITH CONTACTING PLANE AND POINT

SL

CL



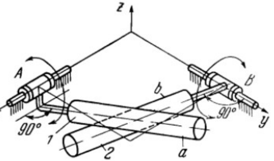
Links *1* and *2* are connected by turning pairs *A* and *B* to the base, and their turning axes are perpendicular but do not intersect. Links *1* and *2* contact each other through point *C* and plane ***a***. Plane ***a*** of link *2* is parallel to the axis of turning pair *B*. Point *C* of contact of links *1* and *2* is located at a constant distance from the turning axis of link *1*.

514

CONTACTING LEVER MECHANISM WITH CONTACTING ROUND CYLINDERS

SL

CL

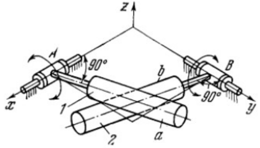


Links *1* and *2* are connected by turning pairs *A* and *B* to the base, and their turning axes are perpendicular and intersect. Links *1* and *2* contact each other through round cylinders *a* and *b*. The axis of cylinder *a* of link *1* is perpendicular to but does not intersect the axis of turning pair *A*. The axis of cylinder ***b*** of link ***2*** is perpendicular to and intersects the axis of turning pair *B*.

515

CONTACTING LEVER MECHANISM WITH CONTACTING ROUND CYLINDERS

SL
CL



Links *1* and *2* are connected by turning pairs *A* and *B* to the base, and their turning axes are perpendicular and intersect. Links *1* and *2* contact each other through round cylinders *a* and *b* whose axes are perpendicular to and intersect the turning axes of links *1* and *2*.

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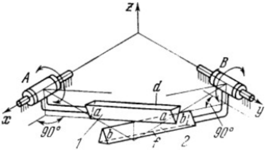
516

CONTACTING LEVER MECHANISM WITH CONTACTING PRISMS

SL
CL



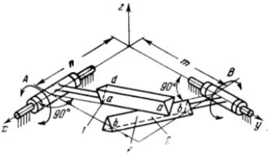
Links *1* and *2* are connected by turning pairs *A* and *B* to the base, and their turning axes are perpendicular and intersect. Links *1* and *2* contact each other through edges *a-a* and *b-b* of triangular prisms *d* and *f*. These edges are perpendicular to but do not intersect the turning axes of links *1* and *2*.

517

CONTACTING LEVER MECHANISM WITH CONTACTING PRISMS

SL

CL



Links *1* and *2* are connected by turning pairs *A* and *B* to the base, and their turning axes are perpendicular and intersect. Links *1* and *2* contact each other through edges *a-a* and *b-b* of triangular prisms *d* and *f*. These edges are perpendicular to and intersect the turning axes of links *1* and *2*. Angle φ_2 of rotation of link *2* is related to angle φ_1 of rotation of link *1* by the equation

$$\varphi_2 = \text{arc tan}\left(\frac{m}{n}\tan\varphi_1\right)$$

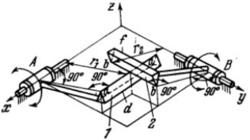
$$\text{for } m = n,\ \varphi_2 = \varphi_1.$$

518

CONTACTING LEVER MECHANISM WITH CONTACTING PRISMS

SL

CL



Links *1* and *2* are connected by turning pairs *A* and *B* to the base, and their turning axes are perpendicular and intersect. Links *1* and *2* contact each other through edges *a-a* and *b-b* of triangular prisms *d* and *f*. Edge *a-a* of link *1* is parallel to the turning axis of this link and edge *b-b* of link *2* is parallel to the turning axis of this link. Angle φ_2 of rotation of link *2* is related to angle φ_1 of rotation of link *1* by the equation

$$\varphi_2 = \arcsin\left(\frac{r_1}{r_2}\sin\varphi_1\right)$$

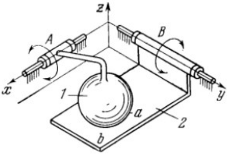
for $r_2 = r_1$, $\varphi_2 = \varphi_1$.

519

CONTACTING LEVER MECHANISM WITH CONTACTING SPHERE AND PLANE

SL

CL



Links *1* and *2* are connected by turning pairs *A* and *B* to the base, and their turning axes are perpendicular and intersect. Links *1* and *2* contact each other through sphere *a* and plane *b* which is parallel to the axis of turning pair *B*. The centre of sphere *a* is located at a constant distance from the turning axis of link *1*.

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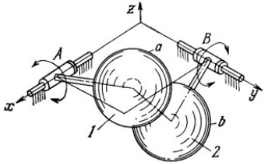
520

CONTACTING LEVER MECHANISM WITH CONTACTING SPHERICAL SURFACES

SL

CL



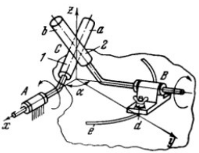
Links *1* and *2* are connected by turning pairs *A* and *B* to the base, and their turning axes intersect at an arbitrarily given angle. Links *1* and *2* contact each other through spherical surfaces *a* and *b*. The centres of spheres *a* and *b* are located at constant distances from the turning axes of links *1* and *2*.

521

CONTACTING LEVER MECHANISM WITH A VARIABLE ANGLE BETWEEN THE TURNING AXES OF THE LEVERS

SL

CL



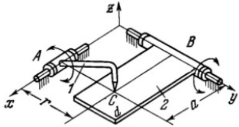
Links *1* and *2* are connected by turning pairs *A* and *B* to the base, and their turning axes intersect at angle α. Links *1* and *2* contact each other through round cylinders *a* and *b* whose axes intersect the turning axes of links *1* and *2*. A device, consisting of screw *d* and arc-shaped guide *e*, enable angle α, between the turning axes of links *1* and *2*, to be varied.

522

CONTACTING LEVER MECHANISM WITH CONTACTING PLANE AND POINT

SL

CL



Links *1* and *2* are connected by turning pairs *A* and *B* to the base, and their turning axes are perpendicular and intersect. Links *1* and *2* contact each other through point *C* and plane *d*. The turning axis of link *2* lies in plane *d*. Point *C* of contact of links *1* and *2* is located at a constant distance from the turning axis of link *1*. Angle φ_2 of rotation of link *2* is related to angle φ_1 of rotation of link *1* by the equation

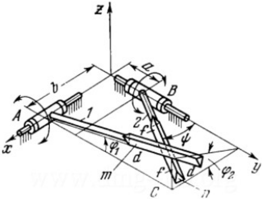
$$\varphi_2 = \text{arc tan}\,\frac{r \sin \varphi_1}{a}$$

523

CONTACTING LEVER MECHANISM WITH CONTACTING PRISMS

SL

CL



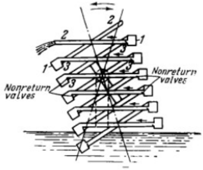
Links *1* and *2* are connected by turning pairs *A* and *B* to the base, and their turning axes are perpendicular and intersect. Links *1* and *2* contact each other through edges *d-d* and *f-f* of triangular prisms *m* and *n*. Edge *f-f* of link *2* intersects its turning axis at the arbitrarily given angle ψ. Edge *d-d* of link *1* is perpendicular to and intersects its turning axis. Angle φ_1 of rotation of link *1* is related to angle φ_2 of rotation of link *2* by the equation

$$\varphi_1 = \operatorname{arc\ tan}\left(\frac{b \tan \varphi_2}{a + \dfrac{b}{\cos \varphi_2} \cot \psi} \right)$$

19. MECHANISMS OF OTHER FUNCTIONAL DEVICES
(524 through 538)

524 LEVER-TYPE PENDULUM PUMP FOR WATER

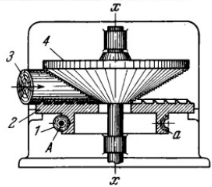
SL
FD



In oscillation of the system, consisting of buckets *1* connected together by tubes *2* having nonreturn valves *3*, water flows consecutively from one bucket to the next and is delivered to the top of the pump. Nonreturn valves *3* permit water flow in the tubes only in the direction of the arrows.

525 DISK-TYPE ROTARY CHIPPER

SL
FD



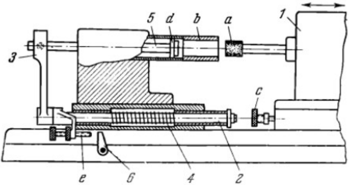
Worm *1*, rotating about fixed axis *A*, meshes with worm wheel *a* of disk *2*. In rotation of worm *1*, disk *2*, having spiral threads on its face, feeds log *3* into conical rotor *4* which rotates rapidly about fixed axis *x-x*. Cutting elements of rotor *4* cut the wood into chips used for particle board, etc.

526

LEVER-TYPE GAUGING DEVICE FOR AN INTERNAL GRINDER

SL

FD

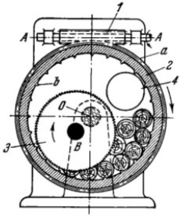


In the grinding process, grinding wheel *a*, mounted on wheelhead slide *1*, enters the hole being ground in workpiece *b*. Rod *2*, carrying cross-piece *3* on its left end, runs with its right end up against the face of screw *c* in slide *1*. Upon travel of slide *1* to the right, grinding wheel *a* is withdrawn from the hole in workpiece *b*. At this, rod *2*, whose end is no longer held by screw *c*, also moves to the right from the action of spring *4*. As a result, plug gauge *d*, mounted on rod *5* which is secured in cross-piece *3*, tries to enter the hole being ground in workpiece *b*. If the hole is undersize, the gauge cannot enter and stop screw *e* will not reach lever *6*. When the smaller diameter of the two-step gauge enters the hole of workpiece *b*, stop screw *e* reaches and changes the position of lever *6*. This changes the rate of infeed, and finish grinding begins. When the required hole diameter is reached, the second step of gauge *d* enters the hole and stop screw *e* shifts lever *6* to the position in which grinding ceases and the grinder is switched off.

527

DRUM-TYPE ROTARY CHIPPER

SL
FD



Worm *1*, rotating about fixed axis *A*, meshes with worm wheel *a* of drum *2* which has internal helical ribs *b*. In rotation of worm *1*, drum *2* rotates about fixed axis *O*, feeding logs to rotor *3* which rotates rapidly about fixed axis *B*. Cutting elements of rotor *3* cut the wood into chips used for particle board, etc. Hatch *4* is for loading logs into the working zone.

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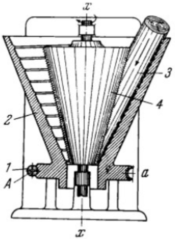
528

CONICAL-TYPE ROTARY CHIPPER

SL
FD



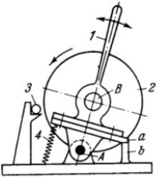
Worm *1*, rotating about fixed axis *A*, meshes with worm wheel *a* of feeding member *2*. Upon rotation of worm *1*, feeding member *2*, having conical threads on its inner surface, pulls log *3* downward and feeds it to the working surface of conical rotor *4* which rotates rapidly about fixed vertical axis *x-x*. Cutting elements of rotor *4* cut the wood into chips used for particle board, etc.

529

LEVER-TYPE PENDULUM SAW

SL

FD



Lever *1*, turning about fixed axis *A*, carries circular saw *2*, rotating about axis *B*. When lever *1* is turned to the left, saw *2* is advanced to timber *3*. This compresses spring *4* which returns the saw to its initial position when lever *1* is released. Stops *a* and *b* locate the saw in its idle position.

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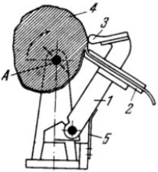
530

LEVER-TYPE KNIFE FOR A POTATO PEELER

SL

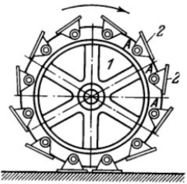
FD



Lever *1* carries knife *2* and feeler *3*. Potato *4* turns about fixed axis *A* and travels longitudinally along this axis (perpendicular to the plane of the drawing) by a mechanism that is not shown. The knife is automatically set to the required depth by feeler *3* which contacts the surface of the potato. The knife and its holder are held to the potato by the force of spring *5*.

531 WHEEL WITH ROCKING GROUSERS

SL
FD



Grousers (shoes) *2* of wheel *1* rock about axes *A* and consecutively come into contact with the ground.

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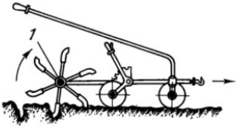
532 LEVER-TYPE PLANTER

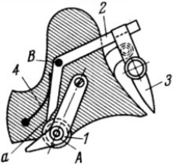
SL
FD



When the machine travels along the field, member *1* rotates due to traction with the soil and makes hollows whose depth can be regulated.

533 LEVER-TYPE DOTTING PEN

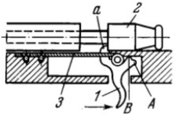
SL
FD



Serrated wheel *1* rotates about axis *A*. Lever *2*, carrying ruling pen *3*, turns about fixed axis *B* and its end *a* engages serrated wheel *1*. As wheel *1* is run along the bevelled edge of the T-square, it rotates and its teeth turn lever *2* and the rigidly attached pen *3* clockwise. When end *a* of lever *2* drops into a tooth space, lever *2* is turned counterclockwise by spring *4*, raising pen *3*. Thus a dot or dash line is drawn on the paper.

534 TRIGGER LEVER FOR A SHOTGUN

SL
FD

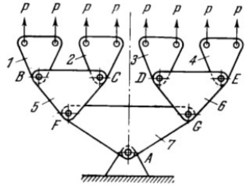


Trigger *1*, hinged to flat spring *3*, has lug *a* which holds striker pin *2* of the bolt in the cocked position. When the trigger is pressed it first turns about point *B* and then about point *A* and striker pin *2* begins to move from right to left due to the action of a spring not shown in the drawing.

535 LEVER-TYPE LOAD ADDING DEVICE

SL

FD

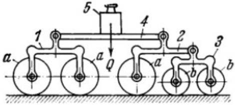


The device consists of members *1*, *2*, *3*, *4*, *5*, *6* and *7* having the same general shape. When eight equal and parallel loads P are applied to members *1*, *2*, *3* and *4*, support A is subject to a load equal to $8P$. Hinges F and G of member *7* are subject to loads of $4P$. Hinges B, C, D and E are subject to loads of $2P$.

536 LEVER-TYPE DEVICE FOR DISTRIBUTING A LOAD ON WHEELS

SL

FD

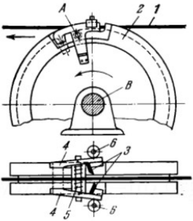


This device consists of levers *1*, *2* and *3* and platform *4*. When load *5* is located symmetrically on the platform its weight Q is distributed uniformly on wheels ***a***. Wheels ***b*** are subject to one half of the load of wheels ***a***. By moving load *5* along platform *4*, other load distributions on the wheels can be obtained.

537

LEVER-TYPE FLYING SHEAR

SL
FD

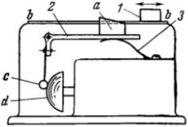


Drum *2* rotates about fixed axis *B*. Members *4*, carrying knives *3*, are connected by turning pairs *A* to drum *2*. The speed of travel of stock *1* being sheared equals the peripheral speed of drum *2*. Spring *5* holds knives *3* apart. The stock is sheared when members *4* pass between rollers *6* which force their diverging ends, holding the knives, together.

538

LEVER-TYPE CALL BELL

SL
FD



In reciprocation of slide block *1* along fixed guide *b-b*, projection *a*, pushed downward by the slide block, turns lever *2*, retracting hammer *c* from cup *d* of the bell. When slide block *1* passes projection *a*, hammer *c*, actuated by spring *3*, strikes cup *d* of the bell.

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SECTION THREE

Linkwork

LW

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1. General-Purpose Four-Link Mechanisms 4L (539 through 581).
2. General-Purpose Five-Link Mechanisms 5L (582 through 589).
3. General-Purpose Six-Link Mechanisms 6L (590 through 608).
4. General-Purpose Multiple-Link Mechanisms ML (609 through 622).
5. Parallel-Crank Mechanisms PC (623 through 640)
6. Crossed-Crank Mechanisms CC (641, 642 and 643)
7. Guiding Mechanisms and Inversors GI (644 through 740)
8. Mechanisms for Mathematical Operations MO (741 through 745)
9. Dwell Mechanisms D (746 through 762)
10. Mechanisms for Generating Curves Ge (763 through 771)
11. Operating Claw Mechanisms of Motion Picture Cameras OC (772 through 780)
12. Balance Mechanisms B (781 through 795)
13. Clutch and Coupling Mechanisms C (796 through 801)
14. Sorting and Feeding Mechanisms SF (802 through 808)
15. Safety Mechanisms S (809, 810 and 811)
16. Governor Mechanisms G (812 through 815)
17. Mechanisms of Measuring and Testing Devices M (816 through 824)
18. Indexing Mechanisms I (825)
19. Mechanisms of Materials Handling Equipment MH (826 through 830)
20. Pantograph Mechanisms P (831 through 857)
21. Brake Mechanisms Br (858 through 876)
22. Hammer, Press and Die Mechanisms HP (877 and 878)
23. Mechanisms of Other Functional Devices FD (879 through 912)

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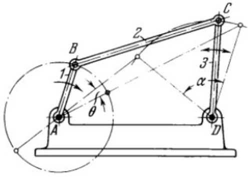
1. GENERAL-PURPOSE FOUR-LINK MECHANISMS
(539 through 581)

539	FOUR-BAR CRANK AND ROCKER-ARM MECHANISM	LW 4L

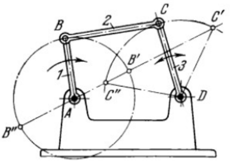


The lengths of the links comply with the conditions: $\overline{AB} < \overline{CD} < \overline{BC} < \overline{AD}$ and $\overline{AB} + \overline{BC} < \overline{AD} + \overline{DC}$. Link *1* is the crank and has complete rotation through 360°. Link *3* is the rocker arm which oscillates through the angle α. Any point of link *2* describes a connecting-rod curve. The angles of forward and reverse oscillation of rocker arm *CD* correspond to angles $180° + \theta$ and $180° - \theta$ of rotation of crank *AB*.

540

FOUR-BAR CRANK AND ROCKER-ARM MECHANISM

LW
4L



The extreme positions, $C'D$ and $C''D$ of rocker arm *3* lie on a straight line passing through point *A*. The angles of forward and reverse oscillation of rocker arm *3* correspond to 180° of rotation of crank *1*. Length $\overline{C'C''}$ equals two lengths of crank *1*.

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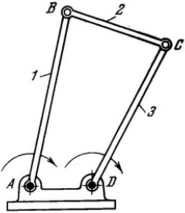
541

FOUR-BAR DRAG-LINK MECHANISM

LW
4L



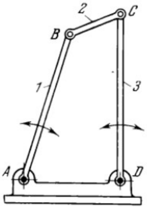
Links *1* and *3* make complete revolutions, i.e. they are both cranks, under the conditions that $\overline{AB}+\overline{AD}<\overline{BC}+\overline{CD}$ and $\overline{AB}>\overline{DC}>\overline{BC}>\overline{AD}$.

542

FOUR-BAR DOUBLE-SWING MECHANISM

LW

4L



The lengths of the links comply with the conditions: $\overline{BC} < \overline{AD} < \overline{AB} < \overline{DC}$ and $\overline{AB} + \overline{BC} < \overline{AD} + \overline{DC}$. Links *1* and *3* are both rocker arms in the sense that they do not rotate completely about points *A* and *D*, but oscillate.

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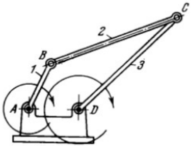
543

FOUR-BAR RHOMBOID DRAG-LINK MECHANISM

LW

4L

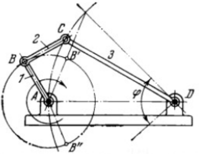


The lengths of the links comply with the conditions: $\overline{AB} = \overline{AD}$ and $\overline{BC} = \overline{CD}$. Link *3* makes one revolution to two revolutions of link *1*. At the extreme positions (dead points) axes *B* and *D* of the links coincide and there is no positive motion of the mechanism unless some device is provided to pass through these dead points or unless the driving link has sufficient flywheel mass.

544

FOUR-BAR RHOMBOID CRANK AND ROCKER-ARM MECHANISM

LW
4L

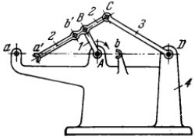


The lengths of the links comply with the conditions: $\overline{AB} = \overline{BC}$ and $\overline{AD} = \overline{CD}$. Angle φ of total swing of rocker arm *3* equals $\varphi = 4 \arcsin \frac{\overline{AB}}{\overline{AD}}$. At the extreme positions, axes *A* and *C* of the links coincide and, unless a special device is provided, driving crank *1* and connecting rod *2* may begin to rotate about axis *A* as a single link. In this case, rocker arm *3* will be stationary and its axis *DC* will coincide with the direction *AD*.

545

FOUR-BAR RHOMBOID MECHANISM WITH SAFETY STOPS

LW
4L



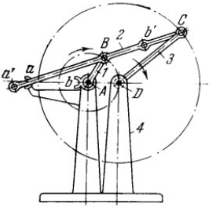
The lengths of the links comply with the conditions: $\overline{AB} = \overline{BC}$ and $\overline{DC} = \overline{DA}$. At the extreme positions (dead points), socket a' and pin b' abut against stops a and b of fixed link *4*. As a result, uncertainty of motion of the mechanism is eliminated. The dimensions $\overline{Aa}$ and $\overline{Ab}$ equal: $\overline{Aa} = \overline{AB} + \overline{Ba'}$ and $\overline{Ab} = \overline{AB} - \overline{Bb'}$.

546

FOUR-BAR RHOMBOID MECHANISM WITH SAFETY STOPS

LW

4L

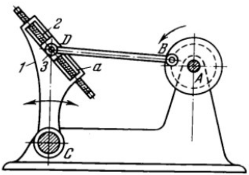


The lengths of the links comply with the conditions: $\overline{AB} = \overline{AD}$ and $\overline{BC} = \overline{DC}$. Link *3* makes one revolution to two revolutions of link *1*. At the extreme positions (dead points), pins *a'* and *b'* of link *2* abut against stops *a* and *b* of base *4*. As a result, uncertainty of motion of the mechanism is eliminated. The dimensions $\overline{Aa}$ and $\overline{Ab}$ equal: $\overline{Aa} = \overline{Ba'} - \overline{AB}$ and $\overline{Ab} = \overline{Bb'} - \overline{AB}$.

547

FOUR-BAR MECHANISM WITH A ROCKER ARM OF VARIABLE LENGTH

LW
4L



The length $\overline{CD}$ of rocker arm *1* is varied by turning screw *2* which adjusts slider *3* along slot *a*. This enables the angle of oscillation of the rocker arm to be regulated.

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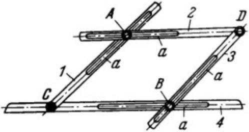
548

FOUR-BAR MECHANISM WITH VARIABLE-LENGTH LINKS

LW
4L



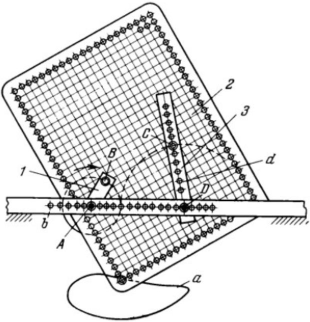
The links of four-bar linkage *ACBD* have slots *a* and two clamping screws at points *A* and *B*. The lengths of the links of the mechanism can be regulated by sliding pivot pins *A* and *B* along the slots *a* of the links and clamping them in the required positions.

549

RAUH FOUR-BAR MECHANISM FOR STUDYING CONNECTING-ROD CURVES

LW

4L



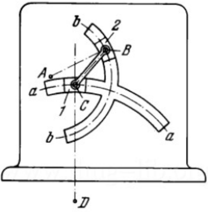
Connecting rod *2* of four-bar linkage *ABCD* is a plane with a large number of holes for setting up a drawing device. In rotation of crank *1*, the drawing device, located in one of the holes of the plane of connecting rod *2*, draws the corresponding connecting-rod curve *a*. Provision is made for varying the lengths of links *DC* and *AD*, using holes *b* and *d*.

550

FOUR-BAR MECHANISM WITH ANNULAR SLIDING BLOCKS

LW

4L



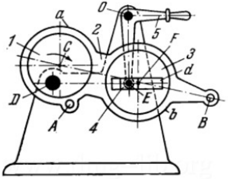
Links *1* and *2* are designed as annular sliding blocks travelling in fixed arc-shaped guides *a*-*a* and *b*-*b* about centres *D* and *A*. This mechanism is equivalent to a four-bar linkage *ABCD*.

551

LINKWORK WITH VARIABLE PATHS OF POINTS ON THE CONNECTING ROD

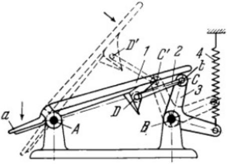
LW

4L



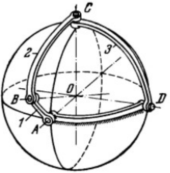
Link *2* of four-bar linkage *DCFE* has two collars *a* and *b* which encircle eccentrics *1* and *3*. These eccentrics rotate about fixed axes *D* and *E*. Upon the rotation of eccentrics *1* and *3*, points *A* and *B* of link *2* describe connecting-rod curves. The paths of points *A* and *B* can be varied by adjusting slide block *4* with axis *E* along slot *d* in eccentric *3*. This is accomplished by turning lever *5* about fixed axis *O*.

552 FOUR-BAR LOCKING LEVER MECHANISM LW 4L



Link *1* of four-bar linkage *ADCB* turns about fixed axis *A*. In the position shown by continuous lines in the drawing, points *A*, *D* and *C* lie on a straight line and the mechanism, due to the action of spring *4*, is locked. Upon depressing pedal *a* of link *1* the mechanism is put into its upper position *AD'C'B* which is shown by dash lines. To return link *1* to its initial locked position, force is applied to its other end. Lug *b* of lever *3* limits the downward motion of link *1*.

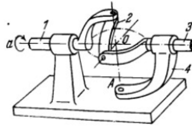
553 FOUR-BAR SPHERICAL CRANK AND ROCKER-ARM MECHANISM LW 4L



The axes of all the kinematic turning pairs should intersect at the common point *O*. When crank *1* is rotated 360° about axis *OA*, rocker arm *3* is turned through a certain angle α about axis *OD*. The magnitude of angle α is determined by the relations between the constant angles $\angle AOB$, $\angle BOC$, $\angle COD$ and $\angle AOD$.

554 FOUR-BAR SPHERICAL MECHANISM

LW
4L



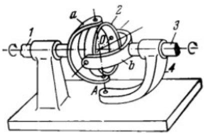
When bracket *4* is put into various positions by turning it about axis *A* and clamping it, rotation from link *1* can be transmitted through link *2* to link *3* under the condition that the axes of all the turning pairs intersect at a single common point *O*. The angle between the turning pairs of any single link equals 90°. Angle φ_1 of rotation of link *1* is related to angle φ_3 of rotation of link *3* by the equation

$$\frac{\tan \varphi_1}{\tan \varphi_3} = \cos \alpha$$

where α is the angle between axes *Oa* and *Ob*.

555 FOUR-BAR SPHERICAL MECHANISM

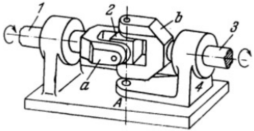
LW
4L



When bracket *4* is put into various positions by turning it about axis *A* and clamping it, rotation can be transmitted from link *1* to link *3* under the condition that the axes of all the turning pairs intersect at a single common point *O*. Links *1* and *3* have arc-shaped forks *a* and *b*. Link *2* is designed as a cylindrical ring.

556 FOUR-BAR SPHERICAL MECHANISM

LW
4L



When bracket *4* is put into various positions by turning it about axis *A* and clamping it, rotation can be transmitted from link *1* to link *3* under the condition that the axes of all the turning pairs intersect at a single common point *O*. Links *1* and *3* have forks *a* and *b*. Link *2* is designed as a cube.

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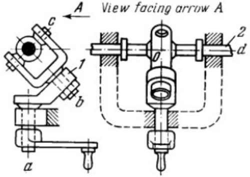
557 FOUR-BAR SPHERICAL MECHANISM

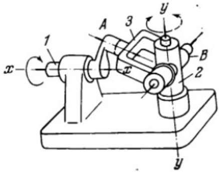
LW
4L



Axes *a*, *b*, *c* and *d* of all the kinematic turning pairs of the mechanism intersect at a single common point *O*. Axes *a* and *d* are perpendicular. Axes *a* and *b* are at an angle of 45°. Upon rotation of crank *1*, link *2* oscillates with an amplitude of 90°.

558 FOUR-BAR SPHERICAL MECHANISM

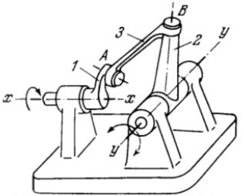
LW
4L



Crank *1* rotates about fixed axis *x-x*. Link *3* is connected by turning pairs *A* and *B* to crank *1* and link *2* which turns about fixed axis *y-y*. In rotation of crank *1* about axis *x-x*, link *2* oscillates about axis *y-y* under the condition that the axes of all the kinematic turning pairs intersect at a single point.

559 FOUR-BAR SPHERICAL MECHANISM

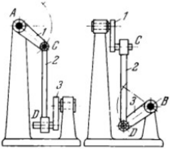
LW
4L



Crank *1* rotates about fixed axis *x-x*. Link *3* is connected by turning pairs *A* and *B* to crank *1* and link *2* which turns about fixed axis *y-y*. In rotation of crank *1* about axis *x-x*, link *2* oscillates about axis *y-y* under the condition that the axes of all the kinematic turning pairs intersect at a single point.

560 FOUR-BAR SPATIAL MECHANISM

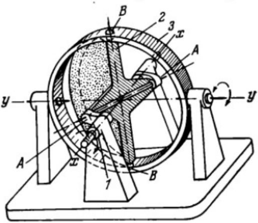
LW
4L



The oscillating motion of link *1* about fixed axis *A* is transformed by means of connecting rod *2* into oscillating motion of link *3* about fixed axis *B*. *C* and *D* are cylindrical pairs capable of both turning and sliding motion. *A* and *B* are turning pairs. Axes *A* and *C* are perpendicular to axes *B* and *D*.

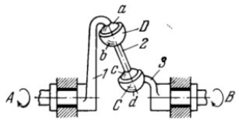
561 FOUR-BAR SPHERICAL MECHANISM

LW
4L



Crank *1* rotates about fixed axis *x-x*. Link *2* is connected by turning pairs *A* and *B* to crank *1* and ring *3* which turns about fixed axis *y-y*. Upon rotation of crank *1* about axis *x-x*, ring *3* oscillates about axis *y-y* under the condition that the axes of all kinematic turning pairs intersect at a single point. Link *2*, hinged to crank *1*, is shown in a cut-away view.

562	FOUR-BAR SPATIAL MECHANISM	LW 4L



Link *1*, having spherical head *a* and rotating about fixed axis *A*, is connected by spherical pair *D* to link *2*. Link *2* has spherical socket *b* and spherical head *c*. Link *3*, rotating about fixed axis *B*, is connected by spherical pair *C* to link *2*. Link *3* has spherical socket *d*. The mechanism transmits rotation between any two arbitrarily located axes *A* and *B*.

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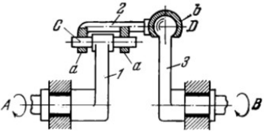
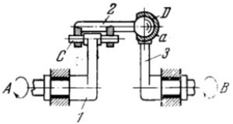
563	FOUR-BAR SPATIAL MECHANISM	LW 4L



Link *1*, rotating about fixed axis *A*, is connected by cylindrical turning and sliding pair *C* to link *2*. Link *3*, rotating about fixed axis *B*, is connected by spherical pair *D* to link *2* which has cylindrical lugs *a* and spherical socket *b*. The mechanism transmits rotation between any two arbitrarily located axes *A* and *B*.

564 FOUR-BAR SPATIAL MECHANISM

LW
4L



Link *1*, rotating about fixed axis *A*, is connected by cylindrical turning and sliding pair *C* to link *2*. Link *2* is connected by spherical pair *D* to link *3* which rotates about fixed axis *B* and has spherical socket *a*. The mechanism transmits rotation between any two arbitrarily located axes *A* and *B*.

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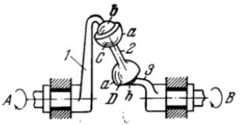
565 FOUR-BAR SPATIAL MECHANISM

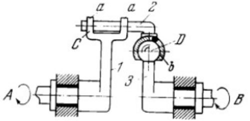
LW
4L



Link *1*, rotating about fixed axis *A*, is connected by spherical pair *C* to link *2* which, in turn, is connected by spherical pair *D* to link *3*. Link *3* rotates about fixed axis *B*. Link *2* has two spherical sockets *a* that fit over spherical heads *b* of links *1* and *3*. The mechanism transmits rotation between any two arbitrarily located axes *A* and *B*.

566 FOUR-BAR SPATIAL MECHANISM

LW
4L



Link *1*, having cylindrical lugs *a* and rotating about fixed axis *A*, is connected by cylindrical turning and sliding pair *C* to link *2*. Link *2* has spherical socket *b* and is connected by spherical pair *D* to link *3* which rotates about fixed axis *B*. The mechanism transmits rotation between any two arbitrarily located axes *A* and *B*.

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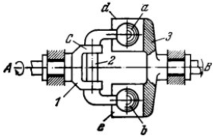
567 FOUR-BAR SPATIAL MECHANISM

LW
4L

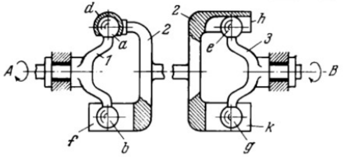


Link *1*, rotating about fixed axis *A*, is connected by turning pair *C* to link *2*. Link *2* is connected by a four-motion kinematic pair to link *3*. This pair consists of two spherical surfaces *a* and *b* which contact flat surfaces *d* and *e* of link *3*. Link *3* rotates about fixed axis *B*. The mechanism transmits rotation between any two arbitrarily located axes *A* and *B*.

568 FOUR-BAR SPATIAL MECHANISM

LW

4L

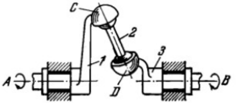


Link *1*, rotating about fixed axis *A*, is connected by a two-motion kinematic pair to link *2*. This pair consists of two spherical surfaces *a* and *b* which contact spherical socket *d* and flat surface *f* of link *2*. Link *3*, rotating about fixed axis *B*, is connected by a two-motion kinematic pair to link *2*. This pair consists of two spherical surfaces *e* and *g* which contact internal cylindrical surface *h* and flat surface *k* of link *2*. The mechanism transmits rotation between any two arbitrarily located axes *A* and *B*.

569 FOUR-BAR SPATIAL MECHANISM

LW

4L

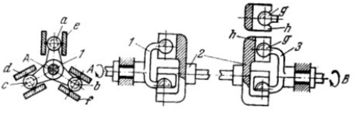


Link *1*, rotating about fixed axis *A*, is connected by spherical pair *C* to link *2*. Link *2* is connected by spherical pair *D* to link *3* which rotates about fixed axis *B*. The mechanism transmits rotation between any two arbitrarily located axes *A* and *B*.

70

FOUR-BAR SPATIAL MECHANISM

LW
4L

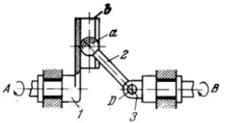


Link *1*, rotating about fixed axis *A*, is connected by a three-motion kinematic pair to link *2*. This pair consists of three spherical surfaces *a*, *b* and *c* of link *1* which contact three flat surfaces *e*, *f* and *d* of link *2*. Link *2* is connected by a two-motion kinematic pair to link *3*. This pair consists of three spherical surfaces *g* of link *3* which contact two flat surfaces and one cylindrical groove *h* of link *2*. Link *3* rotates about fixed axis *B* and its spherical surface *g* slides along cylindrical groove *h* of link *2*. The mechanism transmits rotation between any two arbitrarily located axes *A* and *B*.

571

FOUR-BAR SPATIAL MECHANISM

LW
4L

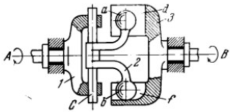


Link *1*, rotating about fixed axis *A*, is connected by a four-motion kinematic pair to link *2*. This pair consists of spherical surface *a* of link *2* which contacts internal cylindrical surface *b* of link *1*. Link *2* is connected by turning pair *D* to link *3* which rotates about fixed axis *B*. The mechanism transmits rotation between any two arbitrarily located axes *A* and *B*.

572

FOUR-BAR SPATIAL MECHANISM

LW
4L



Link *1*, rotating about fixed axis *A*, is connected by cylindrical turning and sliding pair *C* to link *2*. Link *2* is connected by a three-motion kinematic pair to link *3*. This pair consists of two spherical surfaces *a* and *b* which contact flat surface *d* and cylindrical groove *f* of link *3*. Link *3* rotates about fixed axis *B*. The mechanism transmits rotation between any two arbitrarily located axes *A* and *B*.

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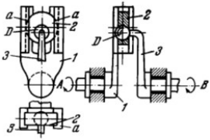
573

FOUR-BAR SPATIAL MECHANISM

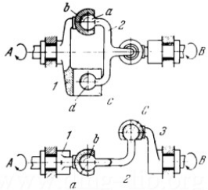
LW
4L



Link *1*, rotating about fixed axis *A*, is connected by a two-motion kinematic pair to link *2* which has the form of a round roller contacting guides *a* of link *1*. Link *2* is connected by spherical pair *D* to link *3* which rotates about fixed axis *B*. The mechanism transmits rotation between any two arbitrarily located axes *A* and *B*.

574 FOUR-BAR SPATIAL MECHANISM

LW
4L



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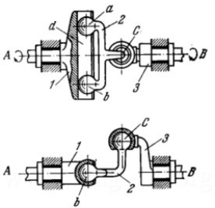
Link *1*, rotating about fixed axis *A*, is connected by a two-motion kinematic pair to link *2*. This pair consists of two spherical surfaces *a* and *d* which contact spherical socket *b* and flat surface *c*. Link *3*, rotating about fixed axis *B*, is connected by spherical pair *C* to link *2*. The mechanism transmits rotation between any two arbitrarily located axes *A* and *B*.

575

FOUR-BAR SPATIAL MECHANISM

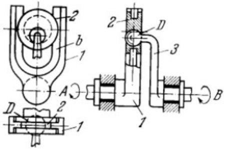
LW
4L



Link *1*, rotating about fixed axis *A*, is connected by a cylindrical turning and sliding pair to link *2*. This pair consists of two spherical surfaces *a* and *b* of link *2* which contact internal cylindrical surface *d* of link *1*. Link *2* is connected by spherical pair *C* to link *3* which rotates about fixed axis *B*. The mechanism transmits rotation between any two arbitrarily located axes *A* and *B*.

576 FOUR-BAR SPATIAL MECHANISM

LW
4L



Link *1*, rotating about fixed axis *A*, is connected by a two-motion kinematic pair to link *2* which has the form of a round roller with rim flanges. Link *2* turns and slides along guides *b* of link *1*. Link *3*, rotating about fixed axis *B*, is connected by spherical pair *D* to link *2*. The mechanism transmits rotation between any two arbitrarily located axes *A* and *B*.

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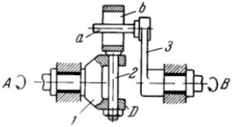
577 FOUR-BAR SPATIAL MECHANISM

LW
4L



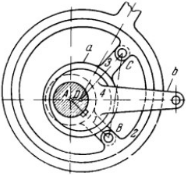
Link *1*, rotating about fixed axis *A*, is connected by turning pair *D* to link *2*. Link *2* is connected by a four-motion kinematic pair to link *3*. This pair consists of flat surface *b* of link *2* and cylindrical pin *a* of link *3*. Link *3* rotates about fixed axis *B*. The mechanism transmits rotation between any two arbitrarily located axes *A* and *B*.

578

SALINGRET FOUR-BAR ECCENTRIC MECHANISM

LW

4L



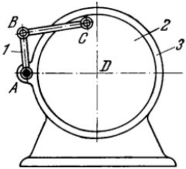
Four-bar linkage *ABCD* consists of links *1*, *2*, *3* and *4*. Of these link *3* carries collar *a* which encircles fixed eccentric *4* having its centre at point *D*. The dimension *AD* can be varied by turning handle *b* of eccentric *4*.

579

FOUR-BAR MECHANISM WITH AN OSCILLATING DISK

LW

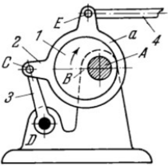
4L



Rocker arm *2* of four-bar linkage *ABCD* is designed in the form of a disk connected by a turning pair to the fixed collar of link *3*. Upon rotation of crank *1*, disk *2*, encircled by fixed collar *3*, oscillates about axis *D*.

580 FOUR-BAR ECCENTRIC MECHANISM

LW
4L



Connecting rod *2* is designed in the form of collar *a* encircling eccentric *1* which rotates about fixed axis *A*. This mechanism is equivalent to four-bar linkage *ABCD* in which the crank length is $\overline{AB}$. Point *E* of connecting rod *2* describes a connecting-rod curve used for transmitting the required motion to link *4*.

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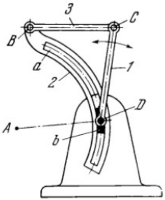
581 FOUR-BAR MECHANISM WITH AN ARC-SHAPED GUIDE BLOCK

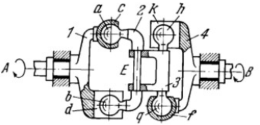
LW
4L



Rocker arm *1* oscillates about fixed axis *D*. Connecting rod *3* is connected by turning pairs *B* and *C* to link *2* and rocker arm *1*. Link *2* has arc-shaped slot *a* which slides along arc-shaped guide block *b* whose radius equals $\overline{AD}$. Upon oscillation of rocker arm *1*, arc-shaped slotted link *2*, having its centre at point *A*, slides along the fixed guide block. This mechanism is equivalent to four-bar double-swing linkage *ABCD*.

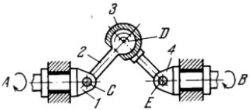
2. GENERAL-PURPOSE FIVE-LINK MECHANISMS
(582 through 589)

582	FIVE-BAR SPATIAL MECHANISM	LW 5L



Link *1*, rotating about fixed axis *A*, is connected by a two-motion kinematic pair to link *2*. This pair consists of spherical socket *c* and flat surface *d* which contact spherical surfaces *a* and *b* of link *2*. Link *2* is connected by turning pair *E* to link *3*. Link *4*, rotating about fixed axis *B*, is connected by a two-motion kinematic pair to link *3*. This pair consists of spherical socket *f* and flat surface *k* which contact spherical surfaces *q* and *h* of link *3*. The mechanism transmits rotation between any two arbitrarily located axes *A* and *B*.

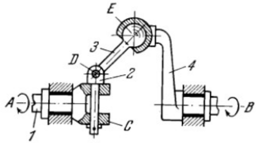
583	FIVE-BAR SPATIAL MECHANISM	LW 5L



Link *1*, rotating about fixed axis *A*, is connected by turning pair *C* to link *2*. Link *3* is connected by spherical pair *D* to link *2* and by turning pair *E* to link *4* which rotates about fixed axis *B*. The mechanism transmits rotation between any two arbitrarily located axes *A* and *B*.

584 FIVE-BAR SPATIAL MECHANISM

LW
5L



Link *1*, rotating about fixed axis *A*, is connected by turning pair *C* to link *2*. Link *3* is connected by turning pair *D* to link *2* and by spherical pair *E* to link *4* which rotates about fixed axis *B*. The mechanism transmits rotation between any two arbitrarily located axes *A* and *B*.

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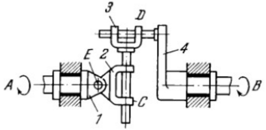
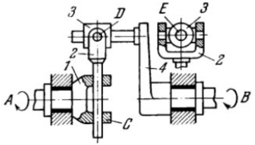
585 FIVE-BAR SPATIAL MECHANISM

LW
5L



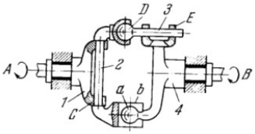
Link *1*, rotating about fixed axis *A*, is connected by turning pair *E* to link *2*. Link *3* is connected by cylindrical turning and sliding pairs *C* and *D* to links *2* and *4*. Link *4* rotates about fixed axis *B*. The mechanism transmits rotation between any two arbitrarily located axes *A* and *B*.

586 FIVE-BAR SPATIAL MECHANISM LW 5L



Link *1*, rotating about fixed axis *A*, is connected by cylindrical turning and sliding pair *C* to link *2*. Link *3* is connected by turning pair *D* to link *2* and by cylindrical turning and sliding pair *E* to link *4* which rotates about fixed axis *B*. The mechanism transmits rotation between any two arbitrarily located axes *A* and *B*.

587 FIVE-BAR SPATIAL MECHANISM LW 5L

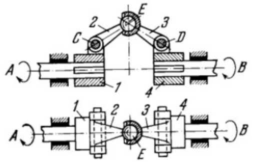


Link *1*, rotating about fixed axis *A*, is connected by turning pair *C* to link *2*. Link *2* is connected by spherical pair *D* to link *3* and by a five-motion kinematic pair to link *4*. This pair consists of spherical surface *a* of link *4* which contacts flat surface *b* of link *2*. Link *3* is connected by cylindrical turning and sliding pair *E* to link *4* which rotates about fixed axis *B*. The mechanism transmits rotation between any two arbitrarily located axes *A* and *B*.

588

FIVE-BAR SYMMETRICAL SPATIAL MECHANISM

LW
5L

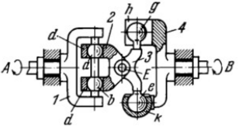


The lengths of links *1* and *2* are equal, respectively, to those of links *4* and *3*. Link *1*, rotating about fixed axis *A*, is connected by turning pair *C* to link *2*. Link *3* is connected by spherical pair *E* to link *2* and by turning pair *D* to link *4* which rotates about fixed axis *B*. The mechanism transmits rotation between any two arbitrarily located axes *A* and *B*.

589

FIVE-BAR SPATIAL MECHANISM

LW
5L

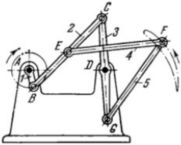


Link *1*, rotating about fixed axis *A*, is connected by a two-motion kinematic pair to link *2*. This pair consists of spherical surfaces *a* and *b* of link *1* which contact internal cylindrical surfaces *d* of link *2*. Link *3* is connected by turning pair *E* to link *2* and by a two-motion kinematic pair to link *4*. This pair consists of spherical surfaces *e* and *g* of link *3* which contact spherical socket *k* and flat surface *h* of link *4*. Link *4* rotates about fixed axis *B*. The mechanism transmits rotation between any two arbitrarily located axes *A* and *B*.

3. GENERAL-PURPOSE SIX-LINK MECHANISMS
(590 through 608)

590 SIX-BAR MECHANISM

LW 6L



Links *4* and *5* are connected to the four-bar linkage *ABCD* with links *1*, *2* and *3*. Point *F* of two-bar group *EFG*, connected to connecting rod *2* and rocker arm *3*, describes a complex path.

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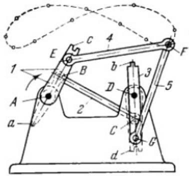
591 SIX-BAR CROSSED-CRANK MECHANISM

LW 6L

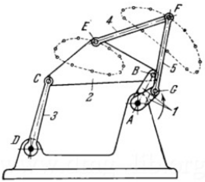


The lengths of the links comply with the conditions: $\overline{AB} = \overline{DC}$ and $\overline{BC} = \overline{AD}$. Thus four-bar mechanism *ABCD* is a crossed-crank linkage, and links *1* and *3* rotate completely about fixed axes *A* and *D*. Links *4* and *5* are connected by turning pairs *E* and *G* to cranks *1* and *3*. Upon rotation of crank *1*, point *F* describes the connecting-rod curve shown in the drawing. Uncertainty of motion of the mechanism is eliminated by the provision of lugs *a* and *b* and slots *c* and *d* on cranks *1* and *3*. In the extreme positions of crossed-crank linkage *ABCD*, lug *a* enters slot *d* and lug *b* enters slot *c*. This enables the mechanism to pass through its extreme positions.

592

SIX-BAR MECHANISM

LW
6L

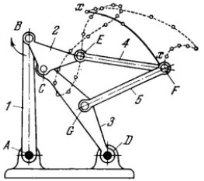


Links *5* and *4* are connected by turning pairs *G* and *E* to bell crank *1* and connecting rod *2* of four-bar linkage *ABCD*. Points of links *2*, *4* and *5* describe complex connecting-rod curves whose shape depends upon the sizes of the links of the mechanism. Thus, for example, upon rotation of crank *1*, points *E* and *F* of link *4* describe the connecting-rod curves shown in the drawing.

593

SIX-BAR MECHANISM WITH A DRIVING CONNECTING ROD

LW
6L

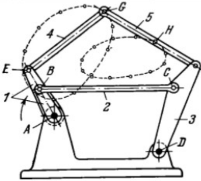


Links *4* and *5* are connected by turning pairs *E* and *G* to connecting rod *2* and rocker arm *3* of double-swing mechanism *ABCD*. Upon rotation of driving connecting rod *2*, points *E* and *F* describe the paths shown in the drawing. Over portion *x*-*x* point *F* travels at higher velocity than over other portions of its path.

594

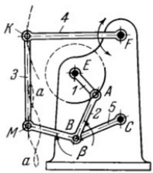
SIX-BAR MECHANISM

LW
6L



Links *4* and *5* are connected by turning pairs *E* and *F* to crank *1* and rocker arm *3* of the four-bar linkage *ABCD*. Points of links *4* and *5* describe complex connecting-rod curves whose shape depends upon the sizes of the links of the mechanism. Thus, for example, upon rotation of crank *1*, points *G* and *H* of link *5* describe the connecting-rod curves shown in the drawing.

CHEBYSHEV SIX-BAR MECHANISM FOR TRANSFORMING OSCILLATION INTO ROTATION



The lengths of the links comply with the conditions:

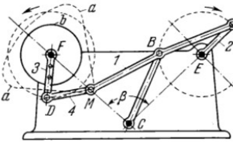
$\overline{AB} = \overline{BC} = \overline{BM} = 1$ $\quad \overline{\beta} = 267°$
$\overline{CE} = 1.38$ $\quad \overline{FE} = 1.23$
$\overline{MK} = \overline{FK} = 1.4$ $\quad \overline{FC} = 1.77$
$\overline{EA} = 0.55$

Point *M* of the connecting rod of four-bar linkage *EABC* describes connecting-rod curve *a-a*. Link *3* is connected by turning pairs *M* and *K* to links *2* and *4*. Link *4* oscillates about fixed axis *F*. For the specified dimensions one complete oscillation of link *4* corresponds to one revolution of crank *1*. The portion of the path of point *A* of crank *1* that corresponds to the return stroke of link *4* is shown by a continuous line.

596

CHEBYSHEV SIX-BAR REVERSING MECHANISM

LW
6L



The lengths of the links comply with the conditions:

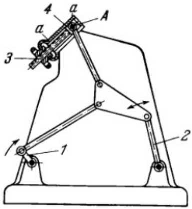
$\overline{AB} = \overline{CB} = \overline{MB} = 1$ $\overline{FC} = 1.39$
$\overline{MD} = \overline{FD} = 0.57$ $\overline{CE} = 1.33$
$\overline{EA} = 0.54$ $\beta = 90^\circ$

Point *M* of connecting rod *1* in four-bar linkage *EABC* describes the symmetrical connecting-rod curve *a-a*. Link *4* is connected by turning pair *M* to connecting rod *1* and by turning pair *D* to link *3*. Link *3* is secured rigidly to flywheel *b* rotating about fixed axis *F*. For the specified dimensions one revolution of crank *2* corresponds to one revolution of link *3* in the opposite direction.

597

SIX-BAR MECHANISM WITH ADJUSTABLE DRIVEN LINK OSCILLATION

LW
6L

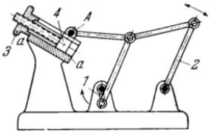


Upon rotation of driving crank *1*, driven link *2* oscillates. The angle of oscillation of link *2* can be varied by changing the position of hinge *A* by means of screw device *3* which moves slide block *4* along fixed guides *a-a*.

598

SIX-BAR MECHANISM WITH ADJUSTABLE DRIVEN LINK OSCILLATION

LW
6L



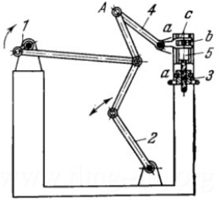
Upon rotation of driving crank *1*, driven link *2* oscillates. The angle of oscillation of link *2* can be varied by changing the position of hinge *A* by means of screw device *3* which moves slide block *4* along fixed guides *a-a*.

599

SIX-BAR MECHANISM WITH ADJUSTABLE DRIVEN LINK OSCILLATION

LW

6L

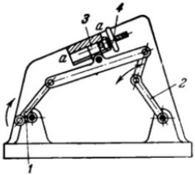


Upon rotation of driving crank *1*, driven link *2* oscillates. The angle of oscillation of link *2* can be varied by changing the position of hinge *A*, with respect to the base, by means of screw device *3* which sets link *4* in various fixed positions. Link *4* is adjusted by moving slide block *5* along stationary guides *a*-*a*. At this pin *b* of slide block *5* slides in slotted lever *c* which is secured rigidly to link *4*.

600

SIX-BAR MECHANISM WITH ADJUSTABLE DRIVEN LINK OSCILLATION

LW
6L

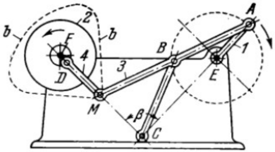


Upon rotation of driving crank *1*, driven link *2* oscillates. The angle of oscillation of link *2* can be varied by means of screw device *4* which moves slide block *3* along fixed guides *a-a*.

601

CHEBYSHEV SIX-BAR PARADOXICAL MECHANISM

LW
6L



The lengths of the links comply with the conditions:

$\overline{AB} = \overline{CB} = \overline{MB} = 1$ $\qquad$ $\overline{FC} = 1.387$

$\overline{EA} = 0.557$ $\qquad$ $\overline{DM} = 0.584$

$\overline{CE} = 1.324$ $\qquad$ $\overline{FD} = 0.123$

$\beta = 90^\circ$

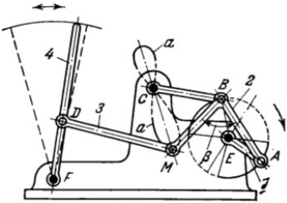
Point *M* of connecting rod *3* in the four-bar linkage *EABC* describes symmetrical connecting-rod curve *b-b*. Link *4* is connected by turning pair *M* to connecting rod *3* and by turning pair *D* to link *2*. Link *2* is designed as a flywheel rotating about fixed axis *F*. For the specified dimensions, one revolution of crank *1* corresponds to two revolutions of flywheel *2* in the same direction or to four revolutions in the opposite direction.

602

CHEBYSHEV SIX-BAR MECHANISM PROVIDING TWO DRIVEN LINK OSCILLATIONS PER CRANK REVOLUTION

LW

6L



The lengths of the links comply with the conditions:

$\overline{AB} = \overline{CB} = \overline{MB} = 1$

$\overline{EA} = 0.54$

$\overline{CE} = 1.29$

$\beta = 80°$

$\overline{MD} = 1.6$

$\overline{FD} = 0.81$

$\overline{CF} = 1.92$

$\overline{EF} = 2.57$

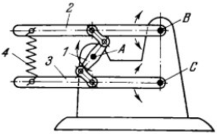
Point *M* of connecting rod *2* in four-bar linkage *EABC* describes symmetrical connecting-rod curve *a-a* which is self-intersecting at point *C*. Link *3* is connected by turning pair *M* to connecting rod *2* and by turning pair *D* to link *4* which oscillates about fixed axis *F*. For the specified dimensions one revolution of crank *1* corresponds to two complete oscillations of link *4* (one slow and one fast).

603

SIX-BAR MECHANISM WITH A SPRING LINK

LW

6L



Link *1* oscillates about fixed axis *A*. Levers *2* and *3* turn about fixed axes *B* and *C*, and are linked together by spring *4*. When link *1* turns counterclockwise about axis *A*, levers *2* and *3* are deviated in opposite directions about axes *B* and *C*, tensioning spring *4*. Spring *4* returns the levers to their initial position.

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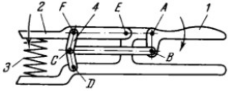
604

SIX-BAR MECHANISM FOR A SPRING COMPRESSOR

LW

6L

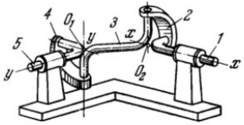


Link *4* is joined to four-bar linkage *ABCD* at point *C*. Link *4* is connected by turning pair *F* to link *2* which turns about fixed axis *E*. When link *1* is turned to close the compressor, link *2* turns about axis *E* and compresses the spring.

605

DOUBLE HOOKE'S JOINT

LW
6L

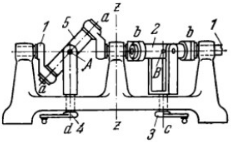


Links *1* and *5* are connected by turning pairs to the base and to links *2* and *4*. Link *3* is connected by turning pairs to links *2* and *4*. Upon rotation of link *1* about axis *x-x*, link *5* rotates about axis *y-y* under the condition that the axes of all pairs intersect at two points O_1 and O_2, three axes at each point.

606

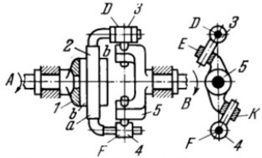
SIX-BAR SPATIAL MECHANISM

LW
6L



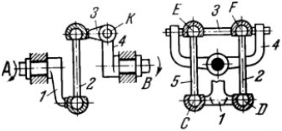
Link *1* is designed in the form of a crankshaft having skew journals with axes *a-a* and *b-b*. The axes of the turning kinematic pairs, connecting links *1*, *4* and *5*, and *1*, *2* and *3*, intersect, respectively, at points *A* and *B*. Upon rotation of link *1* about its fixed axis, links *3* and *4* oscillate about axes *c* and *d*. The mechanism is symmetrical with respect to axis *z-z*.

607 SIX-BAR SPATIAL MECHANISM LW 6L



Link *1*, rotating about fixed axis *A*, is connected by a two-motion kinematic pair to link *2*. This pair consists of cylinder *a* of link *2* confined between two flat surfaces *b* of link *1*. Link *2* is connected by turning pair *D* to link *3* which, in turn, is connected by cylindrical turning and sliding pair *E* to link *5*. Link *4* is connected by cylindrical turning and sliding pairs *F* and *K* to link *2* and link *5* which rotates about fixed axis *B*. The mechanism transmits rotation between any two arbitrarily located axes *A* and *B*.

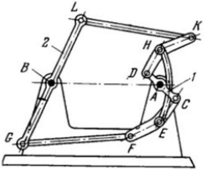
608 SIX-BAR SPATIAL MECHANISM LW 6L



The lengths of the links comply with the conditions: $\overline{EF} = \overline{CD}$ and $\overline{CE} = \overline{DF}$. Link *1* rotates about fixed axis *A* and is connected by two spherical pairs *C* and *D* to links *5* and *2* which, in turn, are connected by two spherical pairs *E* and *F* to link *3*. Link *3* is connected by turning pair *K* to link *4* which rotates about fixed axis *B*. The mechanism transmits rotation between any two arbitrarily located axes *A* and *B*.

4. GENERAL-PURPOSE MULTIPLE-LINK MECHANISMS (609 through 622)

609	**MULTIPLE-BAR MECHANISM FOR TRANSMITTING OSCILLATION TO A PARALLEL SHAFT**	LW ML

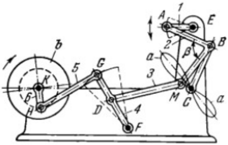


The lengths of the links comply with the conditions: $\overline{AD} = \overline{AC}$, $\overline{DH} = \overline{EC}$, $\overline{HK} = \overline{EF}$, $\overline{DK} = \overline{CF}$, $\overline{LK} = \overline{GF}$ and $\overline{LB} = \overline{BG}$. Upon rotation of crank *1* about fixed axis *A*, link *2* oscillates about fixed axis *B*. The symmetrical dimensions of the links provide for more favourable loading of driven link *2*.

610

CHEBYSHEV EIGHT-BAR MECHANISM FOR TRANSFORMING OSCILLATION INTO ROTATION

LW
ML



The lengths of the links comply with the conditions:

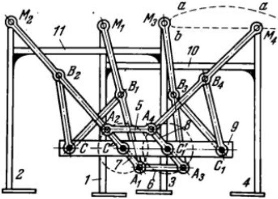
$\overline{AB} = \overline{CB} = \overline{BM} = 1$ $\overline{FD} = 0.71$ $\overline{CF} = 1.6$
$\overline{EA} = 0.545$ $\overline{FG} = 1.33$ $\overline{KF} = 2.11$
$\beta = 80$ $\overline{GH} = 1.36$ $\overline{EF} = 2.6$
$\overline{CE} = 1.325$ $\overline{KH} = 0.39$ $\overline{CK} = 3.29$
$\overline{MD} = 1.61$

Point *M* of link *2* in four-bar linkage *EABC* describes connecting-rod curve *a-a* which is self-intersecting at point *C*. Link *3* is connected by turning pairs *M* and *D* to links *2* and *4*. Link *4* oscillates about fixed axis *F*. Link *5* is connected by turning pairs *G* and *H* to links *4* and *6*. Link *6* is secured rigidly to flywheel *b* and rotates about fixed axis *K*. For the specified dimensions, one complete oscillation of link *1* corresponds to one revolution of link *6*. Flywheel *b* enables the mechanism to pass through the extreme positions (dead points) if the driving link is link *1*.

611

CHEBYSHEV MULTIPLE-BAR WALKING MECHANISM

LW
ML



The lengths of the links comply with the conditions:

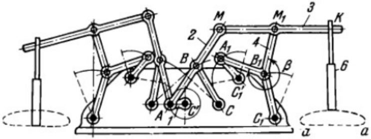
$$\overline{A_1B_1} = \overline{B_1C} = \overline{B_1M_1} = \overline{A_2B_2} = \overline{B_2C} = \overline{B_2M_2} = \overline{A_3B_3} =$$
$$= \overline{B_3C_1} = \overline{B_3M_3} = \overline{A_4B_4} = \overline{B_4C_1} = \overline{B_4M_4} = 1$$
$$\overline{A_1C'} = \overline{A_2C'} = \overline{A_3C_1'} = \overline{A_4C_1'} = 0.355$$
$$\overline{CC'} = \overline{C_1C_1'} = 0.785$$
$$\overline{A_2A_4} = \overline{A_1A_3} = \overline{C'C_1'} = 0.634$$

The mechanism consists of four identical Chebyshev lambda-shaped parallel motions: $C'A_1B_1C$, $C'A_2B_2C$, $C_1'A_3B_3C_1$ and $C_1'A_4B_4C_1$. Together with cranks *7* and *8*, links *5* and *6* form parallel-crank linkage $A_1A_2A_4A_3$. If frame *9* is fixed, then points M_1, M_2, M_3 and M_4 describe connecting-rod curves of a shape resembling curve *a-a* and having an approximately straight portion *b-b* which corresponds to rotation of cranks *7* and *8* through an angle of 180°. Secured rigidly to link *10* are "feet" *1* and *4*, and to link *11* are "feet" *2* and *3*. If frame *9* is moved in rectilinear translation from the position shown in the drawing in either direction, then, while points M_1 and M_4 remain on their straight portions of their relative paths, "feet" *1* and *4* are stationary and "feet" *2* and *3* move along the direction of motion of frame *9*. At the moment that points M_1 and M_4 leave the straight portion of their paths, points M_2 and M_3 begin the straight portion of their paths. At this, "feet" *2* and *3* will be stationary and "feet" *1* and *4* will move along the direction of motion of frame *9*. Thus the mechanism seems to reproduce the motions of the legs of an animal.

612

CHEBYSHEV MULTIPLE-BAR PADDLING MECHANISM

TM
ML



The lengths of the links comply with the conditions:

$\overline{AB} = \overline{CB} = \overline{BM} = \overline{A_1B_1} = \overline{B_1M_1} = 1$ $\beta = 270^\circ$

$\overline{C'A} = 0.297$ $\overline{CC_1'} = 0.74$

$\overline{CC'} = 0.765$ $\overline{CC_1} = 1.3$

$\overline{C_1C_1'} = 1.21$ $\overline{MM_1} = 1.275$

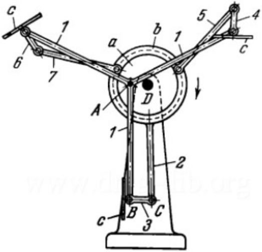
$\overline{C'C_1'} = 1.335$ $\overline{M_1K} = 1.6$

The mechanism is made up of two symmetrically located kinematic chains driven by crank *1*. Point *M* of connecting rod *2* describes a connecting-rod curve having a portion that approximates a straight line. Point *K* of link *3*, which connects points *M* and M_1 of connecting rods *2* and *4* in the linkages $C'ABC$ and $C_1A_1B_1C_1'$, also describes a path having a portion approximating a straight line. As a result, all points of paddle *6* describe path *a-a* in which the paddle enters the water, moves along in it and is withdrawn for the next stroke.

613

MULTIPLE-BAR PADDLE-WHEEL MECHANISM

LW
ML

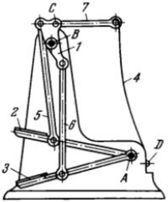


The mechanism is based on four-bar drag-link linkage *ABCD* consisting of links *1*, *2* and *3*. Triple crank *1* rotates about fixed axis *A*. Crank *2* has ring *b* encircling disk *a*. Connected to crank *1* and ring *b* are links *4*, *5*, *6* and *7*. Links *3*, *4* and *6* carry paddles *c* whose plane is perpendicular to the axis of these links.

614

MULTIPLE-BAR DOUBLE-PEDAL DRIVE WITH AN ELASTIC LINK

LW
ML



Pedals *2* and *3* turn about fixed axis *A* and, through tie-rods *5* and *6*, transmit motion to crank *1* which rotates about fixed axis *B*. Crank *1* is connected by turning pair *C* to link *7* which is hinged to flat spring *4*, secured at point *D*. Crank *1* is driven by alternately depressing pedals *2* and *3*. Spring *4* provides force to enable the mechanism to pass through its extreme positions (dead points).

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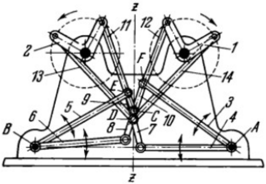
615

MULTIPLE-BAR DOUBLE-DRIVE MECHANISM

LW
ML

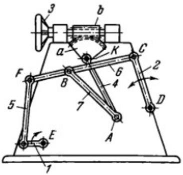


The mechanism consists of two driving cranks *1* and *2* which oscillate links *3*, *4*, *5* and *6* about fixed axes *A* and *B*, the intermediate links being *7*, *8*, *9*, *10*, *11*, *12*, *13* and *14*. There are two turning pairs each at points *C*, *D*, *E* and *F*.

616

MULTIPLE-BAR MECHANISM WITH ADJUSTABLE DRIVEN LINK OSCILLATION

LW
ML

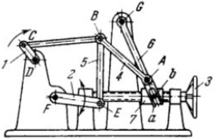


Crank *1* rotates about fixed axis *E*. Through intermediate link *5*, connected by turning pair *F* to connecting rod *6* of four-bar linkage *ABCD*, crank *1* transmits motion to driven link *2*. Turning axis *A* of link *7* is on link *4* which turns about fixed axis *K*. Link *4* is rigidly secured to worm wheel segment *a* which meshes with worm *b* of link *3*. Upon rotation of crank *1*, driven link *2* oscillates. The angle of oscillation of link *2* can be varied by turning link *3* which, by means of worm *b* and worm wheel segment *a*, changes the position of hinge *A*. Adjustment may be made during operation.

617

MULTIPLE-BAR MECHANISM WITH ADJUSTABLE DRIVEN LINK OSCILLATION

LW
ML



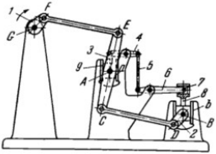
Rocker arm *4* of four-bar linkage *DCBA* turns about fixed axis *A*. Driven link *2* is oscillated through intermediate link *5* which is connected by turning pairs *B* and *E* to links *4* and *2*. Turning axis *A* of link *4* is on link *6* which turns about fixed axis *G*. Link *6* is designed as slotted lever *a* along which pin *b* of nut *7* slides. Nut *7* is connected by a screw pair to screw *3*. Upon rotation of crank *1*, driven link *2* oscillates. The angle of oscillation of link *2* can be varied by changing the position of axis *A* by means of screw *3*. Adjustment may be made during operation.

618

MULTIPLE-BAR MECHANISM WITH ADJUSTABLE SUPPORTING HINGES

LW

ML

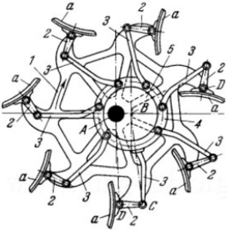


The lengths of the links comply with the conditions: $\overline{GF} = \overline{BD}$, $\overline{FE} = \overline{CD}$ and $\overline{EA} = \overline{CA}$. If turning axes G, A and B lie on a straight line and satisfy the condition $\overline{GA} = \overline{AB}$, then, due to symmetrical arrangement and equal lengths of the links, upon rotation of crank *1*, crank *2* rotates in the same direction and at the same speed as crank *1*. Turning axis A is mounted on slide block *9* which slides along fixed guides *a*. Turning axis B is mounted on slide block *8* which slides along fixed guides *b*. The position of axes A and B can be varied by a link-gear mechanism consisting of links *9*, *3*, *4*, *5*, *6*, *7* and *8*. The various positions of axes A and B are fixed by special clamping devices which are not shown. These devices clamp slide blocks *8* and *9* in their guides *b* and *a*.

619

MULTIPLE-BAR MECHANISM FOR A MOVABLE GROUSER WHEEL

LW
ML

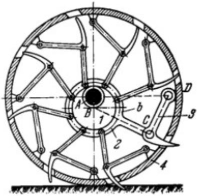


This mechanism is based on double-swing linkage *ABCD* which consists of links *1*, *2* and *4*. Hinge *B* is designed as fixed disk *5* encircled by collar *4*. Grouser *a* is secured rigidly to link *2*. Collar *4* is connected by turning pairs to links *3* which, in turn, are connected by turning pairs to links *2*. Upon rotation of link *1*, link *2* has complex motions during which grousers *a* are in the vertical position after each half revolution of link *1*, with link *2* in the lower position.

620

MULTIPLE-BAR MECHANISM FOR EXTENSIBLE WHEEL LUGS

LW
ML



The mechanism is based on four-bar linkage *ABCD* with driving eccentric *1* which rotates about fixed axis *A*. Link *2* has collar *b* encircling eccentric *1*. The end of link *3* is a wheel lug. The other wheel lugs belong to additional links hinged to link *2* and rim *4*. As the wheel rolls along the ground, the lugs are periodically extended from rim *4* and then withdrawn again into the rim.

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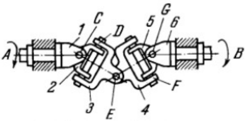
621

SEVEN-BAR SPATIAL MECHANISM

LW
ML



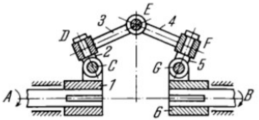
Link *1* rotates about fixed axis *A* and is connected by turning pair *C* to link *2* which, in turn, is connected by turning pair *D* to link *3*. Link *4* is connected by turning pair *E* to link *3* and by turning pair *F* to link *5* which, in turn, is connected by turning pair *G* to link *6*. Link *6* rotates about fixed axis *B*. The mechanism transmits rotation between any two arbitrarily located axes *A* and *B*.

622

SEVEN-BAR SYMMETRICAL SPATIAL MECHANISM

LW

ML

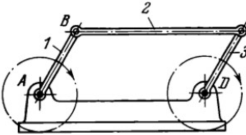


The lengths of links *1*, *2*, and *3* are respectively equal to the lengths of links *6*, *5* and *4*. Link *1* rotates about fixed axis *A* and is connected by turning pair *C* to link *2*. Link *2* is connected by turning pair *D* to link *3*. Link *6* rotates about fixed axis *B* and is connected by turning pair *G* to link *5*. Link *4* is connected by turning pairs *E* and *F* to links *3* and *5*. The mechanism transmits rotation between any two arbitrarily located axes *A* and *B*.

5. PARALLEL-CRANK MECHANISMS
(623 through 640)

623 SIMPLE PARALLEL-CRANK MECHANISM

LW
PC



The lengths of the links comply with the conditions: $\overline{AB} = \overline{DC}$ and $\overline{BC} = \overline{AD}$. The angles of rotation of cranks *1* and *3* are equal. All points of connecting rod *2* describe circles of a radius equal to the length of link *1*. At the extreme positions (dead points) the motion of the mechanism becomes uncertain and it may be transformed into a crossed-crank mechanism.

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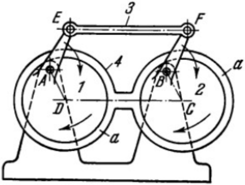
624 ECCENTRIC-TYPE PARALLEL-CRANK MECHANISM

LW
PC



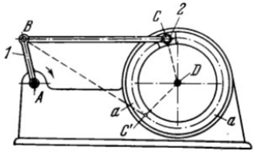
The lengths of the links comply with the conditions: $\overline{AE} = \overline{BF}$, $\overline{AD} = \overline{BC}$, $\overline{DE} = \overline{CF}$ and $\overline{AB} = \overline{DC} = \overline{EF}$. The cranks of the parallel-crank linkage are designed in the form of two eccentrics *1* and *2*, equal in diameter and rotating about fixed axes *A* and *B*. Connecting rod *4* has two collars *a* encircling the eccentrics. Link *3* prevents uncertainty of motion at the extreme positions (dead points).

625

FOUR-BAR PARALLEL-CRANK MECHANISM WITH A CIRCULAR GUIDE

LW

PC



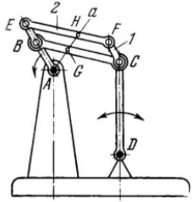
The lengths of the links comply with the conditions: $\overline{AB} = \overline{DC}$ and $\overline{BC} = \overline{AD}$. Link *2* is designed in the form of an arc-shaped slide block which slides along circular guide *a-a* having its centre at point *D*. The mechanism is equivalent to the parallel-crank linkage *ABCD* in which *AB* and *DC* are cranks and *BC* is the connecting rod. At the extreme positions (dead points) the motion of the mechanism becomes uncertain and it may by transformed into a crossed-crank mechanism.

626

SIX-BAR MECHANISM WITH LINKS FORMING A PARALLELOGRAM

LW

PC



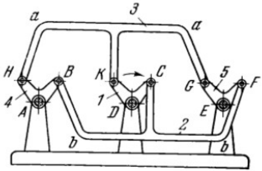
The lengths of the links comply with the conditions: $\overline{BE} = \overline{CF}$ and $\overline{EF} = \overline{BC}$. Connected to four-bar linkage *ABCD* are links *1* and *2* which form parallelogram *BEFC*. Links *BC* and *EF* are always parallel. Points *G* and *H*, lying on any arbitrary radial line *Aa* drawn from point *A*, describe similar paths with a similarity factor *k* equal to $k = \frac{\overline{GB}}{\overline{HE}}$.

627

DOUBLE PARALLEL-CRANK MECHANISM WITH THREE CRANKS

LW

PC



The lengths of the links comply with the conditions: $\overline{AB} = \overline{DC} = \overline{EF} = \overline{AH} = \overline{DK} = \overline{EG}$ and $\overline{BC} = \overline{CF} = \overline{AD} = \overline{DE}$. Rotation of driving crank *1* is transmitted through connecting rods *2* and *3* to cranks *4* and *5*. Planes *a-a* and *b-b* of the connecting rods have a circular translational motion.

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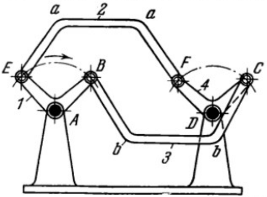
628

DOUBLE PARALLEL-CRANK MECHANISM

LW

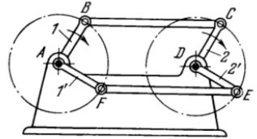
PC



The lengths of the links comply with the conditions: $\overline{AB} = \overline{DC} = \overline{AE} = \overline{DF}$ and $\overline{BC} = \overline{EF}$. Connecting rods *2* and *3* are designed as angle levers having parallel planes *a-a* and *b-b*. Planes *a-a* and *b-b* have a circular translational motion.

629 DOUBLE PARALLEL-CRANK MECHANISM

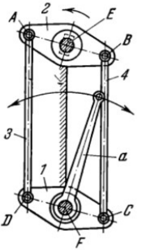
LW
PC



The lengths of the links comply with the conditions: $\overline{AB} = \overline{DC} = \overline{AF} = \overline{DE}$ and $\overline{BC} = \overline{EF}$. Cranks *1* and *1'* are keyed on shaft *A* and cranks *2* and *2'* on shaft *D* at arbitrary but equal angles, not equal to 0° or 180°. As a result, there will be no uncertainty of motion at the extreme positions (dead points) of the mechanism.

630 DOUBLE PARALLEL-CRANK MECHANISM

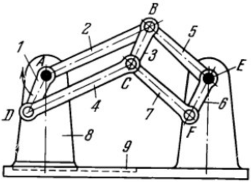
LW
PC



The lengths of the links comply with the conditions: $\overline{EA} = \overline{FD}$, $\overline{EB} = \overline{FC}$ and $\overline{AD} = \overline{EF} = \overline{BC}$. Handle *a* is secured rigidly to link *1* which turns about fixed axis *F*. When lever *a* is turned through a certain angle, links *3* and *4* have a circular translational motion.

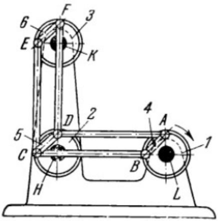
631 DUPLEX PARALLEL-CRANK MECHANISM

LW
PC



The lengths of the links comply with the conditions: $\overline{AB} = \overline{DC}$, $\overline{EB} = \overline{FC}$ and $\overline{AD} = \overline{BC} = \overline{EF}$. Upright *8* slides along guide *9* and can be fixed in various positions. This changes the positions of the adjustable links *2* and *5*. Thus the mechanism can transmit rotation between links *1* and *6* with a variable centre-to-centre distance $\overline{AE}$. In passing through the extreme position (dead point) parallel-crank linkage *CBEF* does not become a crossed-crank one.

632 DOUBLE PARALLEL-CRANK MECHANISM LW PC

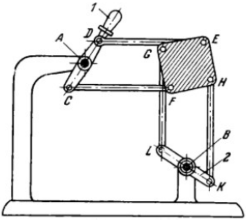


The lengths of the links comply with the conditions: $\overline{EF} = \overline{CD} = \overline{BA}$, $\overline{EC} = \overline{FD} = \overline{HK}$ and $\overline{DA} = \overline{CB} = \overline{HL}$. Links *4*, *5* and *6* are secured rigidly to disks *1*, *2* and *3*. Disks *1*, *2* and *3* turn through equal angles.

633

DUPLEX PARALLEL-CRANK MECHANISM

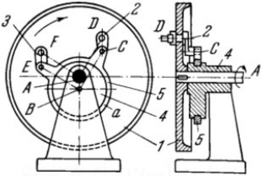
LW
PC



The lengths of the links comply with the conditions: $\overline{DC} = \overline{EF}$, $\overline{DE} = \overline{CF}$, $\overline{GL} = \overline{HK}$, $\overline{GH} = \overline{LK}$, $\overline{AD} = \overline{AC}$ and $\overline{BL} = \overline{BK}$. When handle *1* is turned about fixed axis *A* through a certain angle, link *2* is turned about fixed axis *B* through the same angle.

634 DOUBLE PARALLEL-CRANK MECHANISM

LW
PC



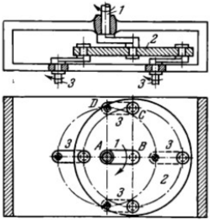
The lengths of the links comply with the conditions: $\overline{AB} = \overline{CD} = \overline{EF}$, $\overline{AD} = \overline{BC}$ and $\overline{AF} = \overline{BE}$. Link *1* rotates about fixed axis *A*. Eccentric *4* is fixed and is encircled by collar *a* of link *5*. Link *5* is connected by turning pair *C* to link *2* which, in turn, is connected by turning pair *D* to link *1*. For the specified dimensions, the links of mechanism *ADCB* constitute a parallel-crank linkage. Link *3* is connected by turning pairs *E* and *F* to links *5* and *1*. Linkage *AFEB* is also of the parallel-crank type. Link *3* enables the mechanism to pass through its extreme positions (dead points).

635

CRANK DRIVE OF A PARALLEL-CRANK MECHANISM

LW

PC



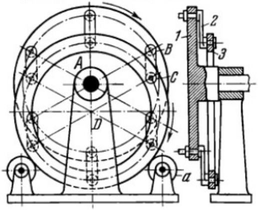
The lengths of the links comply with the conditions: $\overline{AB} = \overline{DC}$ and $\overline{AD} = \overline{BC}$. With each of four driven cranks *3*, driving crank *1* forms a parallel-crank linkage in which the lengths of the links are respectively equal to those of linkage *ABCD*. The common connecting rod of all the linkages is round disk *2*. The angular velocities of cranks *3* are equal.

636

PARALLEL-CRANK RING DRIVE MECHANISM

LW

PC



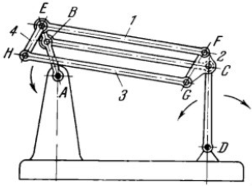
The lengths of the links comply with the conditions: $\overline{AD} = \overline{BC}$ and $\overline{AB} = \overline{DC}$. The mechanism constitutes parallel-crank linkage *ABCD* repeated sixfold. Upon rotation of driving crank *1*, connecting rods *2* have translational motion. Rotation of ring *3* is provided for by rollers *a* on which it rests freely. Links *1* and *3* have equal angular velocities.

637

BAR MECHANISM WITH LINKS FORMING PARALLEL-CRANK LINKAGES

LW

PC



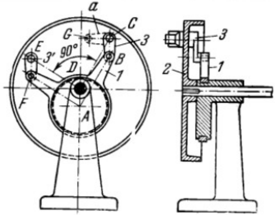
The lengths of the links comply with the conditions: $\overline{BE} = \overline{CF}$, $\overline{HE} = \overline{GF}$ and $\overline{EF} = \overline{BC} = \overline{HG}$. Connected to four-bar linkage *ABCD* are links *1*, *2*, *3* and *4* which form parallel-crank linkages *BEFC* and *EHGF*. Links *BC*, *EF* and *HG* are always parallel to one another.

638

DOUBLE PARALLEL-CRANK MECHANISM WITH AN ECCENTRIC

LW

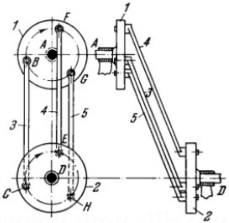
PC



The lengths of the links comply with the conditions: $\overline{AB} = \overline{DC} = \overline{DE} = \overline{AF}$ and $\overline{AD} = \overline{FE} = \overline{BC}$. Two-arm collar *1* encircles a round fixed eccentric with its centre at point *A*. Point *G* of member *a*, secured rigidly to link *3*, has translational motion, describing a circle on flange *2*. Parallel-crank linkage *AFED*, arranged at 90° to parallel-crank linkage *ABCD*, eliminates uncertainty of motion of the mechanism at its extreme positions (dead points).

639 TRIPLE PARALLEL-CRANK MECHANISM

LW
PC



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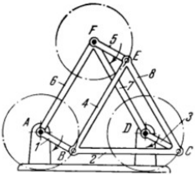
The lengths of the links comply with the conditions: $\overline{AB} = \overline{DC}$, $\overline{AF} = \overline{DE}$, $\overline{AG} = \overline{DH}$ and $\overline{BC} = \overline{FE} = \overline{GH} = \overline{AD}$. The mechanism transmits rotation from shaft A to shaft D. Keyed on shafts A and D are disks *1* and *2* which are connected by turning pairs to connecting rods *3*, *4* and *5*. The mechanism has no uncertainty of motion at its extreme positions (dead points).

640

TRIPLE PARALLEL-CRANK MECHANISM

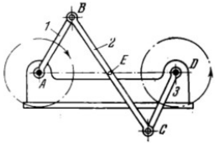
LW
PC



The lengths of the links comply with the conditions: $\overline{AB} = \overline{DC} = \overline{FE}$, $\overline{AD} = \overline{BC}$, $\overline{AF} = \overline{BE}$ and $\overline{DF} = \overline{CE}$. Points B, C and E describe circles of equal radius; links *1*, *3* and *5* have equal angles of rotation. The mechanism transmits rotation from driving link *1* to arbitrarily located links *3* and *5*.

6. CROSSED-CRANK MECHANISMS
(641, 642 and 643)

641	**CROSSED-CRANK MECHANISM**	LW CC



The lengths of the links comply with the conditions: $\overline{AB} = \overline{DC}$ and $\overline{BC} = \overline{AD}$. Cranks *1* and *3* rotate in opposite directions with unequal angular velocities. The transmission ratio is $i_{13} = \frac{\overline{DE}}{\overline{AE}}$. Point E is the intersection of the axis of connecting rod *2* and line $\overline{AD}$.

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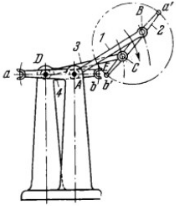
642	**CROSSED-CRANK MECHANISM WITH SAFETY STOPS**	LW CC



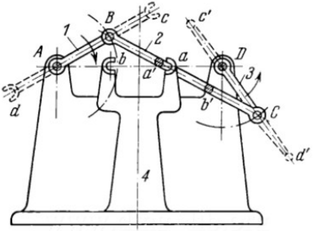
The lengths of the links comply with the conditions: $\overline{AD} = \overline{BC}$ and $\overline{AB} = \overline{DC}$. If the small link AD is fixed, the links will rotate in the same direction. The transmission ratio is $i_{13} = \frac{\overline{AE}}{\overline{DE}}$. Point E is the intersection of the axis of link *2* and line AD. At the extreme positions (dead centres), pins a' and b' of link *2* abut against stops a and b of base *4*. As a result uncertainty of motion of the mechanism is eliminated.

643

CROSSED-CRANK MECHANISM WITH SAFETY STOPS

LW

CC

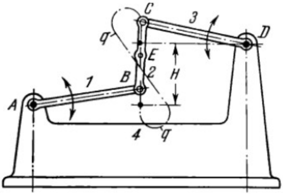


The lengths of the links comply with the conditions: $\overline{AB} = \overline{DC}$ and $\overline{BC} = \overline{AD}$. At the extreme positions (dead centres), pins a' and b' of link *2* abut against stops a and b of base *4*. As a result uncertainty of motion of the mechanism is eliminated. Dash lines show another version of the device for enabling the mechanism to pass through the extreme positions. Here, pins c' and d' of link *3* abut against stops c and d of link *1*.

7. GUIDING MECHANISMS AND INVERSORS

(644 through 740)

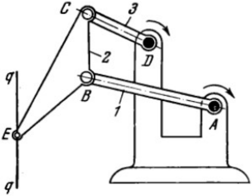
644 | **WATT FOUR-BAR APPROXIMATE STRAIGHT-LINE MECHANISM** | **LW GI**



The lengths of the links of four-bar linkage *ABCD* comply with the conditions: $\overline{AB} = \overline{DC}$, $\overline{BC} = 0.62\overline{AB}$, $\overline{BE} = \overline{EC}$ and $\overline{AD} = 2.15\overline{AB}$. When link *1* turns about fixed axis *A*, point *E* of link *2* describes path *q-q* of which the portion *H* is approximately a straight line.

---

645 | **WATT FOUR-BAR APPROXIMATE STRAIGHT-LINE MECHANISM** | **LW GI**

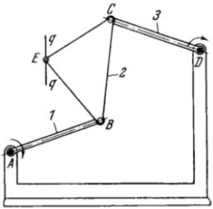


The lengths of the links of four-bar linkage *ABCD* comply with the conditions: $\overline{AD} = \overline{BE} = 0.68\overline{AB}$, $\overline{DC} = 0.51\overline{AB}$, $\overline{CB} = 0.49\overline{AB}$ and $\overline{CE} = 1.1\overline{AB}$. When link *1* turns about fixed axis *A*, point *E* of link *2* describes a path of which portion *q-q* is approximately a straight line.

646

WATT FOUR-BAR APPROXIMATE STRAIGHT-LINE MECHANISM

LW
GI

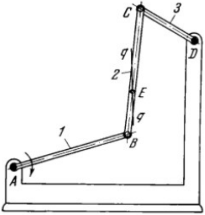


The lengths of the links of four-bar linkage *ABCD* comply with the conditions: $\overline{BC} = \overline{DC} = \overline{AB}$, $\overline{CE} = 0.86\overline{AB}$, $\overline{AD} = 2.6\overline{AB}$ and $\overline{BE} = 0.82\overline{AB}$. When link *1* turns about fixed axis *A*, point *E* of link *2* describes a path of which portion *q-q* is approximately a straight line.

647

WATT FOUR-BAR APPROXIMATE STRAIGHT-LINE MECHANISM

LW
GI

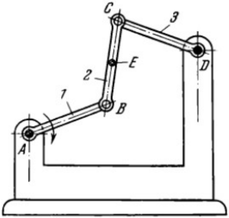


The lengths of the links of four-bar linkage *ABCD* comply with the conditions: $\overline{BC} = 1.05\,\overline{AB}$, $\overline{DC} = 0.55\,\overline{AB}$ and $\overline{BE} = 0.36\overline{AB}$. When link *1* turns about fixed axis *A*, point *E* of link *2* describes a path of which portion *q-q* is approximately a straight line.

648

WATT FOUR-BAR APPROXIMATE STRAIGHT-LINE MECHANISM

LW
GI

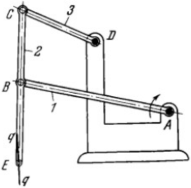


The lengths of the links of four-bar linkage $ABCD$ comply with the conditions: $\overline{AB} = \overline{BC} = \overline{DC}$, $\overline{BE} = 0.52\overline{AB}$ and $\overline{AD} = 2.24\overline{AB}$. When link *1* turns about fixed axis A, point E of link *2* describes a path of which a certain portion is approximately a straight line.

649

WATT FOUR-BAR APPROXIMATE STRAIGHT-LINE MECHANISM

LW
GI



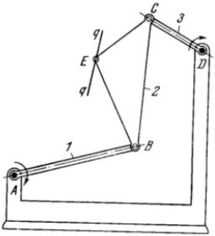
The lengths of the links of four-bar linkage $ABCD$ comply with the conditions: $\overline{BC} = \overline{DC} = 0.5\overline{AB}$ and $\overline{AD} = 0.66\,\overline{AB}$. When link *1* turns about fixed axis A, point E of link *2* describes a path of which portion *q-q* is approximately a straight line.

650

WATT FOUR-BAR APPROXIMATE STRAIGHT-LINE MECHANISM

LW

GI



The lengths of the links of four-bar linkage *ABCD* comply with the conditions: $\overline{AD} = 1.84\overline{AB}$, $\overline{BE} = 0.76\overline{AB}$, $\overline{BC} = 1.03\overline{AB}$, $\overline{EC} = 0.55\overline{AB}$ and $\overline{DC} = 0.52\overline{AB}$. When link *1* turns about fixed axis *A*, point *E* of link *2* describes a path of which portion *q-q* is approximately a straight line.

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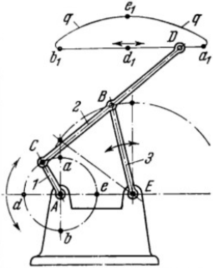
651

CHEBYSHEV FOUR-BAR APPROXIMATE STRAIGHT-LINE MECHANISM

LW

GI

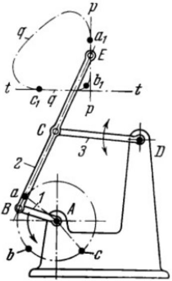


The lengths of the links of four-bar linkage *ACBE* comply with the conditions: $\overline{CB} = \overline{BE} = \overline{BD} = 2.5\overline{AC}$ and $\overline{AE} = 2\overline{AC}$. When link *1* rotates about fixed axis *A*, point *D* of link *2* describes path *q-q*. Upon motion of point *C* along arc *a-d-b*, point *D* travels along approximately straight line a_1-d_1-b_1.

652

CHEBYSHEV FOUR-BAR APPROXIMATE STRAIGHT-LINE MECHANISM

LW
GI

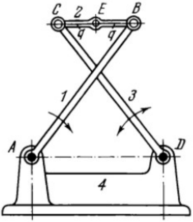


The lengths of the links of four-bar linkage *ABCD* comply with the conditions: $\overline{BC}=\overline{DC}=\overline{CE}=2.17\overline{AB}$ and $\overline{AD}=2.83\overline{AB}$. When link *1* rotates about fixed axis *A*, point *E* of link *2* describes path *q-q*. Upon motion of point *B* along arc *a-b-c*, point *E* travels along portions a_1-b_1 and b_1-c_1 which approximate two mutually perpendicular straight lines *p-p* and *t-t*.

653

CHEBYSHEV FOUR-BAR APPROXIMATE STRAIGHT-LINE MECHANISM

LW
GI

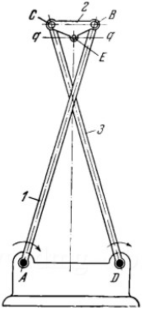


The lengths of the links of four-bar linkage *ABCD* comply with the conditions: $\overline{AB}=\overline{DC}$, $\overline{BE}=\overline{EC}=0.25\overline{AB}$ and $AD=0.8\overline{AB}$. When link *1* turns about fixed axis *A*, point *E* of link *2* describes a path of which portion *q-q* is approximately a straight line.

654

CHEBYSHEV FOUR-BAR APPROXIMATE STRAIGHT-LINE MECHANISM

LW
GI

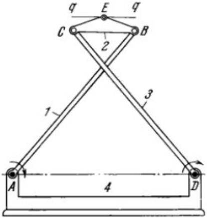


The lengths of the links of four-bar linkage *ABCD* comply with the conditions: $\overline{AB}=\overline{DC}=6.2\,\overline{BC}$, $\overline{CE}=\overline{BE}=0.6\,\overline{BC}$ and $\overline{AD}=2.36\,\overline{BC}$. When link *1* turns about fixed axis *A*, point *E* of link *2* describes a path of which a certain portion approximates straight line *q-q*, parallel to *AD*.

655

CHEBYSHEV FOUR-BAR APPROXIMATE STRAIGHT-LINE MECHANISM

LW
GI



The lengths of the links of four-bar linkage *ABCD* comply with the conditions: $\overline{AB} = \overline{DC} = \overline{AD} = 4\,\overline{CB}$ and $\overline{CE} = \overline{EB} = 0.53\,\overline{BC}$. When link *1* turns about fixed axis *A*, point *E* of link *2* describes a path of which a certain portion approximates straight line *q-q*, parallel to *AD*.

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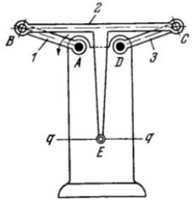
656

CHEBYSHEV FOUR-BAR APPROXIMATE STRAIGHT-LINE MECHANISM

LW
GI

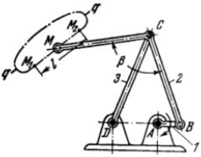


The lengths of the links of four-bar linkage *ABCD* comply with the conditions: $\overline{AB} = \overline{DC}$, $\overline{BC} = 2.5\overline{AB}$ and $\overline{BE} = \overline{CE} = 2.25\overline{AB}$. When link *1* turns about fixed axis *A*, point *E* of link *2* describes a path of which a certain portion approximates straight line *q-q*, parallel to *AD*.

657

CHEBYSHEV FOUR-BAR APPROXIMATE STRAIGHT-LINE MECHANISM

LW
GI

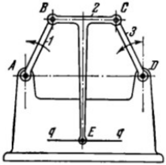


The lengths of the links comply with the conditions: $\overline{AD} = 2.16\,\overline{AB}$, $\overline{BC} = \overline{DC} = \overline{MC} = 4.34\,\overline{AB}$ and angle $\beta = \angle\,MCD = 100°$. When link *1* rotates about fixed axis *A*, point *M* of connecting rod *2*, in four-bar linkage *ABCD*, describes connecting-rod curve *q-q* of which portion M_1M_2, of a length $l \cong 2.66\overline{AB}$, is approximately a straight line.

658

ROBERTS FOUR-BAR APPROXIMATE STRAIGHT-LINE MECHANISM

LW
GI

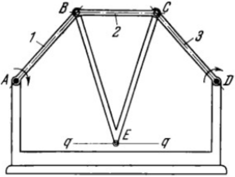


The lengths of the links of four-bar linkage *ABCD* comply with the conditions: $\overline{AB} = \overline{CD}$, $\overline{AD} = 1.89\overline{AB}$, $\overline{BC} = 1.1\overline{AB}$ and $\overline{BE} = \overline{CE} = 1.96\overline{AB}$. When link *1* turns about fixed axis *A*, point *E* describes a path of which portion *q-q* is approximately a straight line.

659

ROBERTS FOUR-BAR APPROXIMATE STRAIGHT-LINE MECHANISM

LW
GI

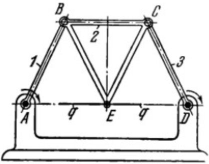


The lengths of the links of four-bar linkage *ABCD* comply with the conditions: $\overline{AB} = \overline{DC}$, $\overline{AD} = 2.2\overline{AB}$, $\overline{BC} = 0.9\overline{AB}$ and $\overline{BE} = \overline{CE} = 1.4\overline{AB}$. When link *1* turns about fixed axis *A*, point *E* of link *2* describes a path of which a certain portion approximates straight line *q-q*, parallel to *AD*.

660

ROBERTS FOUR-BAR APPROXIMATE STRAIGHT-LINE MECHANISM

LW
GI

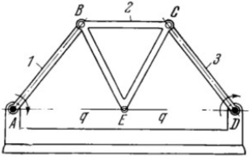


The lengths of the links of four-bar linkage *ABCD* comply with the conditions: $\overline{AB} = \overline{BE} = \overline{CE} = \overline{DC}$ and $\overline{AD} = 2\overline{BC}$. When link *1* turns about fixed axis *A*, point *E* of link *2* describes a path of which a certain portion approximates straight line *q-q*, passing through points *A* and *D*.

661

ROBERTS FOUR-BAR APPROXIMATE STRAIGHT-LINE MECHANISM

LW
GI

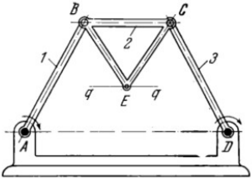


The lengths of the links of four-bar linkage $ABCD$ comply with the conditions: $\overline{AB} = \overline{DC}$ and $\overline{BE} = \overline{CE} = \frac{1}{2}\sqrt{4\overline{AB}^2 + \overline{AD}^2 - 2\,\overline{AD}\,(\overline{AD} - \overline{BC})}$. When link *1* turns about fixed axis A, point E of link **2** describes a path of which a certain portion approximates straight line *q-q*, passing through points A and D.

662

ROBERTS FOUR-BAR APPROXIMATE STRAIGHT-LINE MECHANISM

LW
GI

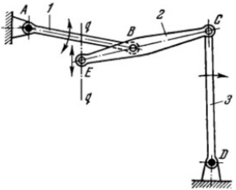


The lengths of the links of four-bar linkage $ABCD$ comply with the conditions: $\overline{AB} = \overline{DC}$ and $\overline{BE} = \overline{EC} < \overline{AB}$. When link *1* turns about fixed axis A, point E of link **2** describes a path of which a certain portion approximates straight line *q-q*, parallel to AD.

663

EVANS FOUR-BAR APPROXIMATE STRAIGHT-LINE MECHANISM

LW
GI



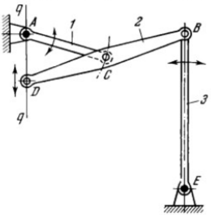
When link *1* turns about fixed axis *A*, point *E* of link *2* travels along path *q-q* which is approximately a straight line under the condition that point *B* describes a circular arc approximately coinciding with the elliptic path it would have if points *B* and *C* of link *2* travelled exactly along straight lines. The accuracy with which the path of point *E* approximates a straight line increases with the lengths $\overline{AB}$ and $\overline{DC}$ of links *1* and *3*.

664

EVANS FOUR-BAR APPROXIMATE STRAIGHT-LINE MECHANISM

LW

GI



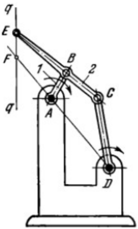
The lengths of the links of four-bar linkage *ACBE* comply with the condition: $\overline{AC} = \overline{BC} = \overline{CD}$. When link *1* turns about fixed axis *A*, point *D* of link *2* describes a path of which portion *q-q* is approximately a straight line.

665

EVANS FOUR-BAR APPROXIMATE STRAIGHT-LINE MECHANISM

LW

GI

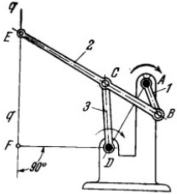


The lengths of the links of four-bar linkage *ABCD* comply with the conditions: $\overline{BC} = 1.4\,\overline{AB}$, $\overline{BE} = 2.4\overline{AB}$, $\overline{DC} = 2.6\overline{AB}$, $\overline{AD} = 3.4\overline{AB}$ and $\overline{AF} = 2\overline{AB}$. When link *1* turns about fixed axis *A*, point *E* of link *2* describes a path of which a certain portion approximates straight line *q-q*, passing through point *F*.

666 EVANS FOUR-BAR APPROXIMATE STRAIGHT-LINE MECHANISM

LW

GI

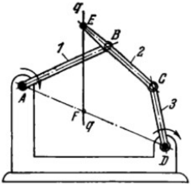


The lengths of the links of four-bar linkage *ABCD* comply with the conditions: $\overline{BC} = 1.92\overline{AB}$, $\overline{CE} = 2.92\overline{AB}$, $\overline{CD} = 2\ \overline{AB}$, $\overline{AD} = 2.3\overline{AB}$ and $\overline{DF} = 2.87\overline{AB}$. When link *1* turns about fixed axis *A*, point *E* of link *2* describes a path of which a certain portion approximates straight line *q-q*, passing through point *F* on straight line *DF*.

667 EVANS FOUR-BAR APPROXIMATE STRAIGHT-LINE MECHANISM

LW

GI

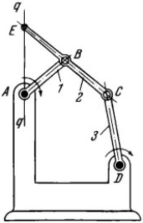


The lengths of the links of four-bar linkage *ABCD* comply with the conditions: $\overline{BC} = 0.65\overline{AB}$, $\overline{BE} = 0.32\ \overline{AB}$, $\overline{AD} = 1.66\overline{AB}$, $\overline{DC} = 0.66\overline{AB}$ and $\overline{AF} = 0.7\overline{AB}$. When link *1* turns about fixed axis *A*, point *E* of link *2* describes a path of which a certain portion approximates straight line *q-q* passing through point *F* on straight line *AD*.

668

EVANS FOUR-BAR APPROXIMATE STRAIGHT-LINE MECHANISM

LW
GI

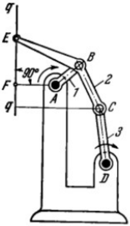


The lengths of the links of four-bar linkage *ABCD* comply with the conditions: $\overline{AB} = \overline{BE} = \overline{BC}$, $\overline{AD} = 2.2\overline{AB}$ and $\overline{DC} = 1.3AB$. When link *1* turns about fixed axis *A*, point *E* of link *2* describes a path of which a certain portion approximates straight line *q-q*, passing through point *A*.

669

EVANS FOUR-BAR APPROXIMATE STRAIGHT-LINE MECHANISM

LW
GI

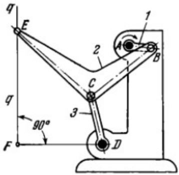


The lengths of the links of four-bar linkage *ABCD* comply with the conditions: $\overline{AD} = 3.64\ \overline{AB}$, $\overline{BC} = 1.54\overline{AB}$, $\overline{DC} = 18.2\overline{AB}$, $\overline{CE} = 3.72\overline{AB}$, $\overline{BE} = 2.27\overline{AB}$ and $\overline{AF} = 1.27\overline{AB}$. When link *1* turns about fixed axis *A*, point *E* of link *2* describes a path of which a certain portion approximates straight line *q-q*, passing through point *F*.

670

EVANS FOUR-BAR APPROXIMATE STRAIGHT-LINE MECHANISM

LW
GI

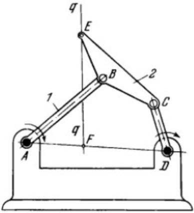


The lengths of the links of four-bar linkage *ABCD* comply with the conditions: $\overline{AD} = 4.9\overline{AB}$, $\overline{BC}=3.56\overline{AB}$, $\overline{DC} = 2.21\overline{AB}$, $\overline{CE} = 4.4\overline{AB}$, $\overline{BE} = 5.33\overline{AB}$ and $\overline{DF} = 4\overline{AB}$. When link *1* turns about fixed axis *A*, point *E* of link *2* describes a path of which a certain portion approximates straight-line *q-q*, passing through point *F*.

671

EVANS FOUR-BAR APPROXIMATE STRAIGHT-LINE MECHANISM

LW
GI

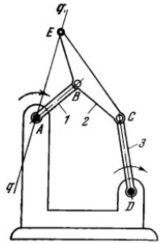


The lengths of the links of four-bar linkage *ABCD* comply with the conditions: $\overline{AD} = 1.41\overline{AB}$, $\overline{BC} = 0.55\overline{AB}$, $\overline{DC} = 0.48\overline{AB}$, $\overline{CE}= 0.96\overline{AB}$, $\overline{BE} = 0.45\overline{AB}$ and $\overline{AF} = 0.55\overline{AB}$. When link *1* turns about fixed axis *A*, point *E* of link *2* describes a path of which a certain portion approximates straight line *q-q*, passing through point *F* on straight line *AD*.

672

EVANS-DE JONGE FOUR-BAR APPROXIMATE STRAIGHT-LINE MECHANISM

LW
GI



The lengths of the links of four-bar linkage *ABCD* comply with the conditions: $\overline{AB} = \overline{BE} = \overline{BC}$, $\overline{AD} = 2.15\overline{AB}$, $\overline{CE} = 2\overline{AB}$ and $\overline{DC} = 1.3\overline{AB}$. When link *1* turns about fixed axis *A*, point *E* of link *2* describes a path of which a certain portion approximates straight line *q-q*, passing through point *A*.

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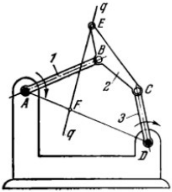
673

EVANS-DE JONGE FOUR-BAR APPROXIMATE STRAIGHT-LINE MECHANISM

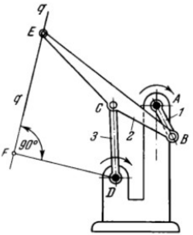
LW
GI



The lengths of the links of four-bar linkage *ABCD* comply with the conditions: $\overline{AD} = 1.65\overline{AB}$, $\overline{BC} = \overline{DC} = 0.65\,\overline{AB}$, $\overline{CE} = 0.95\overline{AB}$, $\overline{BE} = 0.35\overline{AB}$ and $\overline{AF} = 0.7\overline{AB}$. When link *1* turns about fixed axis *A*, point *E* of link *2* describes a path of which a certain portion approximates straight line *q-q*, passing through point *F*.

674 EVANS-DE JONGE FOUR-BAR APPROXIMATE STRAIGHT-LINE MECHANISM

LW
GI



The lengths of the links of four-bar linkage *ABCD* comply with the conditions: $\overline{BC} = 1.92\overline{AB}$, $\overline{DC} = 2\overline{AB}$, $\overline{CE} = 2.84\overline{AB}$, $\overline{EB} = 4.77\overline{AB}$, $\overline{AD} = 2.3\ \overline{AB}$ and $\overline{DF} = 3.08\overline{AB}$. When link *1* turns about fixed axis *A*, point *E* of link *2* describes a path of which a certain portion approximates straight line *q-q* passing through point *F*.

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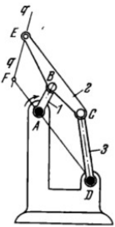
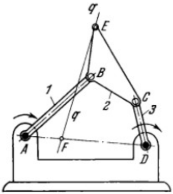
675 EVANS-DE JONGE FOUR-BAR APPROXIMATE STRAIGHT-LINE MECHANISM

LW
GI



The lengths of the links of four-bar linkage *ABCD* comply with the conditions: $\overline{BC} = \overline{AF} = 1.36\overline{AB}$, $\overline{DC} = 2.37\overline{AB}$, $\overline{AD} = 3.1\overline{AB}$, $\overline{BE} = 2.09\overline{AB}$ and $\overline{EC} = 3.46\overline{AB}$. When link *1* turns about fixed axis *A*, point *E* of link *2* describes a path of which a certain portion approximates straight line *q-q* passing through point *F* on straight line *AD*.

676 EVANS-DE JONGE FOUR-BAR APPROXIMATE STRAIGHT-LINE MECHANISM LW GI



The lengths of the links of four-bar linkage *ABCD* comply with the conditions: $\overline{AD} = 1.4\overline{AB}$, $\overline{BC} = 0.57\overline{AB}$, $\overline{DC} = 0.48\overline{AB}$, $\overline{CE} = 0.9AB$, $\overline{BE} = 0.55\overline{AB}$ and $\overline{AF} = 0.41\overline{AB}$. When link *1* turns about fixed axis *A*, point *E* of link *2* describes a path of which a certain portion approximates straight line *q-q* passing through point *F* on straight line *AD*.

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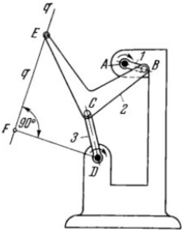
677 EVANS-DE JONGE FOUR-BAR APPROXIMATE STRAIGHT-LINE MECHANISM LW GI

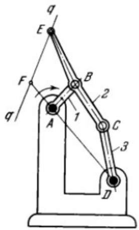


The lengths of the links of four-bar linkage *ABCD* comply with the conditions: $\overline{AD} = \overline{BE} = 4.5\overline{AB}$, $\overline{BC} = 3\overline{AB}$, $\overline{DC} = 2\,\overline{AB}$, $\overline{CE} = 3.8\,\overline{AB}$ and $\overline{DF} = 4\overline{AB}$. When link *1* turns about fixed axis *A*, point *E* of link *2* describes a path of which a certain portion approximates straight line *q-q* passing through point *F*.

678

EVANS-DE JONGE FOUR-BAR APPROXIMATE STRAIGHT-LINE MECHANISM

LW
GI



The lengths of the links of four-bar linkage *ABCD* comply with the conditions: $\overline{AD} = 3.1\overline{AB}$, $\overline{BC} = 1.55\overline{AB}$, $\overline{DC} = \overline{BE} = 1.9\overline{AB}$, $\overline{CE} = 3.45\overline{AB}$ and $\overline{AF} = 1.09\overline{AB}$. When link *1* turns about fixed axis *A*, point *E* of link *2* describes a path of which a certain portion approximates straight line *q-q* passing through point *F* on the extension of straight line *DA*.

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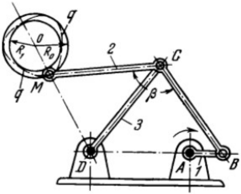
679

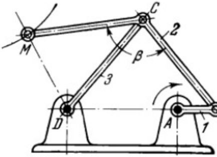
CHEBYSHEV FOUR-BAR APPROXIMATE CIRCLE-TRACING MECHANISM

LW
GI



The lengths of the links of four-bar linkage *ABCD* comply with the conditions: $\overline{BC} = \overline{DC} = \overline{CM} = 3.12\overline{AB}$, $\overline{AD} = 2.94\overline{AB}$ and angle $\beta = 120°$. When link *1* turns about fixed axis *A*, point *M* of link *2* describes path *q-q* which approximates a circle of radius R_1 or R_0, where $\Delta R = R_0 - R_1$ is a small value.

680 CHEBYSHEV FOUR-BAR APPROXIMATE CIRCLE-TRACING MECHANISM LW GI



The lengths of the links of four-bar linkage *ABCD* comply with the conditions: $\overline{BC} = \overline{DC} = \overline{CM} = 2.94\overline{AB}$, $\overline{AD} = 2.83\overline{AB}$ and angle $\beta = 124°$. When link *1* turns about fixed axis *A*, point *M* of link *2* describes a path of which a certain portion approximates a circular arc.

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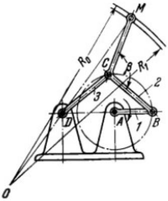
681 CHEBYSHEV FOUR-BAR APPROXIMATE CIRCLE-TPACING MECHANISM LW GI

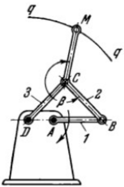


The lengths of the links of four-bar linkage *ABCD* comply with the conditions: $\overline{BC} = \overline{DC} = \overline{CM} = 1.55\overline{AB}$, $\overline{AD} = 1.36AB$ and angle $\beta = 110°$. When link *1* turns about fixed axis *A*, point *M* of link *2* describes a path which approximates a circular arc of radius R_1 or R_0 where $\Delta R = R_0 - R_1$ is a small value.

682

CHEBYSHEV FOUR-BAR APPROXIMATE CIRCLE-TRACING MECHANISM

LW
GI

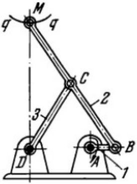


The lengths of the links of four-bar linkage *ABCD* comply with the conditions: $\overline{BC} = \overline{DC} = \overline{CM} = 1.27\,\overline{AB}$, $\overline{AD} = 0.5\,AB$ and angle $\beta = 237°$. When link *1* turns about fixed axis *A*, point *M* of link *2* describes a path approximating circular arc *q-q*.

683

CHEBYSHEV FOUR-BAR APPROXIMATE CIRCLE-TRACING MECHANISM

LW
GI

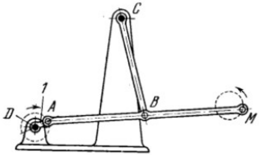


The lengths of the links of four-bar linkage *ABCD* comply with the conditions: $\overline{BC} = \overline{DC} = \overline{CM} = 3\,\overline{AB}$ and $\overline{AD} = 2.5\,\overline{AB}$. When link *1* turns about fixed axis *A*, point *M* of link *2* describes a path of which a certain portion approximates a circular arc.

684

CHEBYSHEV FOUR-BAR REVERSING APPROXIMATE CIRCLE-TRACING MECHANISM

LW
GI

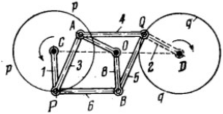


The lengths of the links of four-bar linkage *DABC* comply with the conditions: $\overline{AB} = \overline{BC} = \overline{BM} = 1$, $\overline{AD} = 0.136$ and $\overline{CD} = 1.41$. For the specified dimensions, point *M* describes a path that differs only slightly from a circle. When link *1* is rotated clockwise, point *M* moves counterclockwise in what is approximately a circle.

685

ZHUKOVSKY REVERSING CIRCLE-TRACING MECHANISM

LW
GI



The lengths of the links comply with the conditions: $\overline{PA} = \overline{AQ} = \overline{QB} = \overline{BP} = m$, $\overline{OA} = \overline{OB} = n$, $\overline{OC} = \overline{OD} = a$, $\overline{CP} = \overline{DQ} = r$ and $m^2 - n^2 = a^2 - r^2 = \text{const}$. Figure *AQBP* is a rhombus and figure *AOBP* is a rhomboid linkage. When link *1* rotates about fixed axis *C*, point *P* describes circle *p-p* of radius *r*, and point *Q* describes circle *q-q* of the same radius *r*. Therefore, by adding link *2*, shown by dash lines, the mechanism can be made to transmit rotation with a mean transmission ratio i_m between links *1* and *2* per full revolution equal to

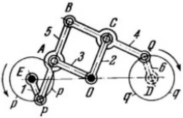
$$i_m = \frac{\omega_1}{\omega_2} = -1,$$

i.e. link *2* rotates in the opposite direction to link *1*.

686

DELONÉ REVERSING CIRCLE-TRACING MECHANISM

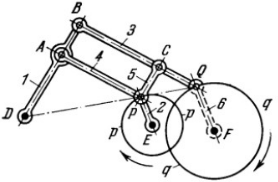
LW
GI



The lengths of the links comply with the condition: $\overline{AB} = \overline{BC} = \overline{CO} = \overline{OA} = \overline{AP} = \overline{CQ}$. Figure *ABCO* is a rhombus linkage. Link *1* rotates about fixed axis *E* and is connected by turning pair *P* to link *5*. Links *2* and *3* turn about fixed axis *O* and are connected by turning pairs *C* and *A* to links *4* and *5*. When link *1* rotates about axis *E*, point *P* describes circle *p-p* of radius $\overline{EP}$ and point *Q* describes circle *q-q* of radius $\overline{DQ} = \overline{EP}$. Points *E*, *O* and *D* lie on a straight line. Therefore, by adding link *6*, shown by dash lines, the mechanism can be made to transmit rotation with constant transmission ratio i_{16} between links *1* and *6* equal to $i_{16} = \frac{\omega_1}{\omega_6} = -1$. Directions *EP* and *DQ* of links *1* and *6* are always parallel. Links *1* and *6* rotate in opposite directions.

687 DELONÉ CIRCLE-TRACING MECHANISM

LW
GI



The lengths of the links comply with the conditions: $\overline{AB} = \overline{PC}$, $\overline{BC} = \overline{AP}$ and $\overline{DB} : \overline{BQ} = \overline{DA} : \overline{AP} = \overline{PC} : \overline{CQ} = \overline{EP} : \overline{FQ}$. Figure $ABCP$ is a parallelogram linkage. Points D, P and Q lie on a straight line. Link *1* turns about fixed axis D and is connected by turning pairs A and B to links *4* and *3*. Link *2* rotates about fixed axis E and is connected by turning pairs P to links *4* and *5*. When link *2* rotates about axis E, point P describes circle p-p of radius $\overline{EP}$ and point Q of link *3* describes circle q-q of radius $\overline{FQ}$. Therefore, by adding link *6*, shown by dash lines, the mechanism can be made to transmit rotation with constant transmission ratio i_{26} between links *2* and *6* equal to

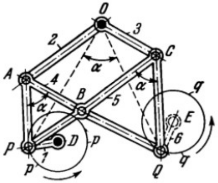
$$i_{26} = \frac{\omega_2}{\omega_6} = 1.$$

Directions EP and FQ of links *2* and *6* are always parallel. Links *2* and *6* rotate in the same direction.

688

DELONÉ CIRCLE-TRACING MECHANISM

LW
GI



The lengths of the links comply with the conditions: $\overline{AB} = \overline{OC} = \overline{AP}$ and $\overline{AO} = \overline{BC} = \overline{CQ}$. Figure *AOCB* is a parallelogram linkage. Link *1* rotates about fixed axis *D* and is connected by turning pair *P* to link *4*. Links *2* and *3* turn about fixed axis *O* and are connected by turning pairs *A* and *C* to links *4* and *5*. When link *1* rotates about axis *D*, point *P* describes circle *p-p* of radius $\overline{DP}$ and point *Q* describes circle *q-q* of radius $\overline{EQ} = \overline{DP}$. Therefore, by adding link *6*, shown by dash lines, the mechanism can be made to transmit rotation with a mean transmission ratio between links *1* and *6* equal to

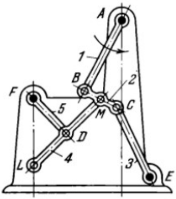
$$i_{\text{m}} = \frac{\omega_1}{\omega_6} = 1.$$

Links *1* and *6* rotate in the same direction. Angle $\angle POQ$ is always equal to α.

689

APPROXIMATE STRAIGHT-LINE MECHANISM

LW
GI

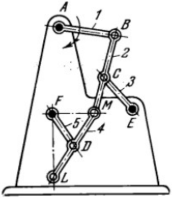


The lengths of the links comply with the conditions: $\overline{AB} = \overline{EC}$, $\overline{BC} = 0.44\,\overline{AB}$, $\overline{BM} = \overline{MC}$, $\overline{MD} = \overline{FD} = \overline{DL} = 0.61\overline{AB}$, $\overline{AE} = 2\,\overline{AB}$, $\overline{EF} = 1.72\,\overline{AB}$ and $\overline{AF} = 1.44\,\overline{AB}$. Link *1* turns about fixed axis *A* and is connected by turning pair *B* to link *2*. Link *3* turns about fixed axis *E* and is connected by turning pair *C* to link *2*. Link *4* is connected by turning pair *M* to link *2* and by turning pair *D* to link *5* which turns about fixed axis *F*. When link *1* turns about axis *A*, point *L* of link *4* describes a path of which a certain portion approximates a straight line.

690

SIX-BAR APPROXIMATE STRAIGHT-LINE MECHANISM

LW
GI

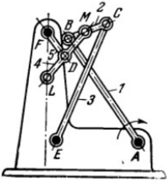


The lengths of the links comply with the conditions: $\overline{BM} = 1.46\,\overline{AB}$, $\overline{EC} = \overline{BC} = 0.77\,\overline{AB}$, $\overline{FD} = \overline{DM} = \overline{DL} = 0.7\,\overline{AB}$, $\overline{FE} = 1.46\,\overline{AB}$, $\overline{AE} = 2\,\overline{AB}$ and $\overline{AF} = 1.54\,\overline{AB}$. Link *1* turns about fixed axis *A* and is connected by turning pair *B* to link *2*. Link *2* is connected by turning pair *C* to link *3* which turns about fixed axis *E*. Link *4* is connected by turning pairs *M* and *D* to links *2* and *5*. Link *5* turns about fixed axis *F*. When link *1* turns about axis *A*, point *L* of link *4* describes a path of which a certain portion approximates a straight line.

691

CHEBYSHEV SIX-BAR APPROXIMATE STRAIGHT-LINE MECHANISM

LW
GI

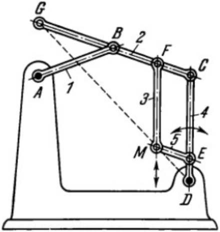


The lengths of the links comply with the conditions: $\overline{AB} = \overline{EC}$, $\overline{BC} = 0.32\overline{AB}$, $\overline{AE} = 0.46\overline{AB}$, $\overline{BM} = \overline{MC}$, $\overline{MD} = \overline{FD} = \overline{DL} = 0.25\overline{AB}$, $\overline{AF} = 1.14\,\overline{AB}$ and $\overline{EF} = 0.85\,\overline{AB}$. Link *1* turns about fixed axis *A* and is connected by turning pair *B* to link *2*. Link *2* is connected by turning pairs *M* and *C* to links *4* and *3*. Link *3* turns about fixed axis *E*. Link *4* is connected by turning pair *D* to link *5* which turns about fixed axis *F*. When link *1* turns about axis *A*, point *L* of link *4* describes a path of which a certain portion approximates a straight line.

692

APPROXIMATE STRAIGHT-LINE AND PANTOGRAPH MECHANISM

LW
GI



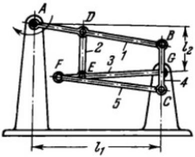
The lengths of the links comply with the conditions: $\overline{AB} = \overline{BC} = \overline{BG}$, $\overline{FC} = \overline{ME}$ and $\overline{FM} = \overline{EC}$. If link *4* is sufficiently long, point G of link *2* travels approximately along a straight line. Links *2*, *3*, *4* and *5* form a pantograph linkage. As a result, point M also travels approximately along a straight line, describing a path similar to that of point G, the similarity factor k being equal to

$$k = \frac{\overline{DE}}{\overline{DC}}$$

693

WATT SIX-BAR APPROXIMATE STRAIGHT-LINE MECHANISM

LW
GI



The lengths of the links comply with the conditions:

$$\overline{BD} = \overline{EG} = \frac{\overline{AB}\sqrt{5} - \overline{AB}}{2}$$

$$\overline{CF} = \overline{GF} = \frac{\overline{AB}\sqrt{5} + \overline{AB}}{4}$$

$$\overline{BC} = \overline{DE} = l_2 = \frac{\overline{AB}}{3}$$

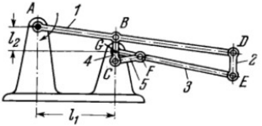
$$l_1 = \overline{AB}$$

Link *1* turns about fixed axis *A* and is connected by turning pairs *D* and *B* to links *2* and *4*. Link *3* turns about fixed axis *G* and is connected by turning pairs *E* and *F* to links *2* and *5*. Link *4* is connected by turning pairs *B* and *C* to links *1* and *5*. When link *1* turns about axis *A*, point *C* of link *4* describes a path of which a certain portion approximates a straight line.

694

WATT SIX-BAR APPROXIMATE STRAIGHT-LINE MECHANISM

LW
GI



The lengths of the links comply with the conditions:

$$\overline{BD} = \overline{EG} = \frac{\overline{AB}\sqrt{5} + \overline{AB}}{2}$$

$$\overline{CF} = \overline{FG} = \frac{\overline{AB}\sqrt{5} - \overline{AB}}{4}$$

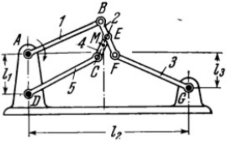
$$l_1 = \overline{AB} \quad \text{and} \quad l_2 = \overline{BC} = \overline{DE}$$

Link *1* turns about fixed axis *A* and is connected by turning pairs *D* and *B* to links *2* and *4*. Link *3* turns about fixed axis *G* and is connected by turning pairs *E* and *F* to links *2* and *5*. Link *4* is connected by turning pairs *B* and *C* to links *1* and *5*. When link *1* turns about axis *A*, point *C* of link *4* describes a path of which a certain portion approximates a straight line.

695

WATT SIX-BAR APPROXIMATE STRAIGHT-LINE MECHANISM

LW
GI

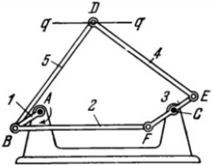


The lengths of the links comply with the conditions: $\overline{AB} = \overline{GF} = \overline{DC}$, $\overline{BF} = 0.62\,\overline{AB}$, $\overline{BE} = \overline{EF}$, $\overline{ME} = \overline{MC}$, $l_1 = \overline{BE} + \overline{EC}$, $l_2 = \overline{AB} + \overline{FG}$ and $l_3 = \overline{BF}$. Link *1* turns about fixed axis *A* and is connected by turning pair *B* to link *2*. Link *2* is connected by turning pair *E* to link *4* and by turning pair *F* to link *3* which turns about fixed axis *G*. Link *5* turns about fixed axis *D* and is connected by turning pair *C* to link *4*. When link *1* turns about axis *A*, point *M* of link *4* describes a path of which a certain portion approximates a straight line.

696

SIX-BAR APPROXIMATE STRAIGHT-LINE MECHANISM

LW
GI

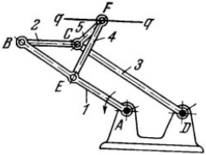


The lengths of the links comply with the conditions: $\overline{AB} = \overline{CF} = \overline{CE}$, $\overline{BD} = \overline{DE} = 4.27\,\overline{AB}$ and $\overline{AC} = 4.52\,\overline{AB}$. Link *1* turns about fixed axis *A* and is connected by turning pair *B* to links *2* and *5*. Link *4* is connected by turning pair *D* to link *5* and by turning pair *E* to link *3* which turns about fixed axis *C*. Link *2* is connected by turning pair *F* to link *3*. When link *1* turns about axis *A*, point *D* describes a path of which a certain portion approximates straight line *q-q*.

697

SIX-BAR APPROXIMATE STRAIGHT-LINE MECHANISM

LW
GI

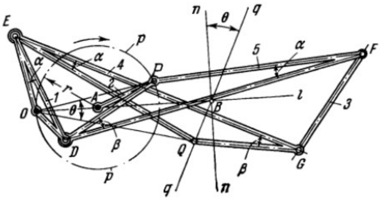


The lengths of the links comply with the conditions: $\overline{BC} = \overline{AD}$, $\overline{AB} = \overline{DC}$, $\overline{AE} = \overline{EB} = \overline{EF}$ and $\overline{CF} = 0.27\overline{AB}$. Figure $ABCD$ is a parallelogram linkage. Link *1* turns about fixed axis A and is connected by turning pairs E and B to links *4* and *2*. Link *2* is connected by turning pair C to links *5* and *3* Link *3* turns about fixed axis D. Links *4* and *5* are connected by turning pair F. When link *1* turns about axis A, point F describes a path of which a certain portion approximates straight line q-q.

698

SYLVESTER-KEMPE EXACT STRAIGHT-LINE MECHANISM

LW
GI

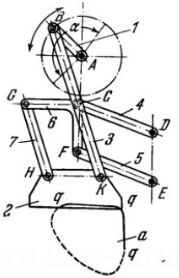


The lengths of the links comply with the conditions: $\overline{DE} = \overline{FG}$, $\overline{DF} = \overline{EG}$, $\overline{PF} = \overline{EQ}$, $\overline{DP} = \overline{GQ}$, $\overline{AB} = \overline{OB} - \overline{OA}$, $\overline{OB} = \frac{K^2}{2\,\overline{OA}\cos\theta}$ and $\frac{\overline{OE}}{\overline{OD}} = \frac{\overline{QE}}{\overline{QG}} = \frac{\overline{PF}}{\overline{PD}}$, where $\theta = \alpha + \beta$ and $K^2 = \overline{EQ} \times \overline{QG} - \overline{EO} \times \overline{OD}$. Figure *DEGF* is a crossed-crank linkage. When link *2* turns about fixed axis *A*, point *P* of triangle *PFD*, belonging to link *5*, describes a circle of radius $r = \overline{AP}$. Point *Q* of triangle *QEG*, belonging to link *4*, describes straight line *q-q* which passes through point *B* and makes angle θ with straight line *n-n* perpendicular to *OABl*. Another feature of the mechanism is that angle $\angle QOP$ remains constant and equal to θ.

699

APPROXIMATE STRAIGHT-LINE MECHANISM

LW
GI

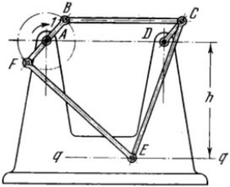


The lengths of the links comply with the conditions: $\overline{BC} = \overline{CK} = \overline{CD} = 1$, $\overline{AB} = 0.46$, $\overline{AD} = 1.3$, $\overline{CD} = FE$, $\overline{CF} = \overline{DE}$, $\overline{GC} = \overline{HK}$ and $\overline{GH} = \overline{CK}$. The mechanism is based on four-bar linkage $ABCD$. Point K of link *3* describes a connecting-rod curve of shape *a* of which portions *q-q* approximate two mutually perpendicular straight lines. Link *2* is connected by turning pair K to link *3*. To have all points of link *2* describing path *a*, i.e. to obtain translational motion of link *2*, a translation device is provided. It consists of links *4*, *5*, *6* and *7* which form parallelogram linkages $DCFE$ and $KCGH$.

700

KOSTITSYN APPROXIMATE STRAIGHT-LINE MECHANISM

LW
GI

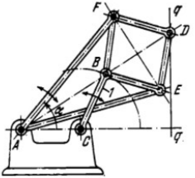


The lengths of the links comply with the conditions: $\overline{AB} = \overline{DC} = \overline{AF}$, $\overline{AD} = \overline{BC} = 4\,\overline{AB}$ and $\overline{FE} = \overline{CE} = 5\,\overline{AB}$. When crank *1* turns about fixed axis *A*, point *E* describes a path that approximates straight line *q-q* parallel to line of centres *AD*.

701

PEAUCELLIER-LIPKIN EXACT STRAIGHT-LINE MECHANISM

LW
GI



The lengths of the links comply with the conditions: $\overline{BF} = \overline{FD} = \overline{DE} = \overline{BE} = a$, $\overline{AF} = \overline{AE} = b$ and $\overline{AC} = \overline{CB}$. When link *1* turns about fixed axis *C*, point *D* travels along straight line *q-q* which is perpendicular to *AC*. The mechanism always satisfies the condition: $\overline{AB} \times \overline{AD} = b^2 - a^2 = \text{const}$.

The polar equation of straight line *q-q* is

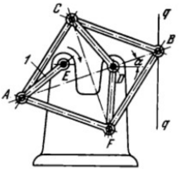
$$\overline{AD}\cos\alpha = \frac{b^2 - a^2}{2\overline{AC}} = \text{const}.$$

Directions *AD* and *FE* are always mutually perpendicular.

702

PEAUCELLIER-LIPKIN EXACT STRAIGHT-LINE MECHANISM

LW
GI



The lengths of the links comply with the conditions: $\overline{AC} = \overline{CB} = \overline{BF} = \overline{FA} = a$, $\overline{DF} = \overline{DC} = b$ and $\overline{EA} = \overline{ED}$. When link *1* turns about fixed axis *E*, point *B* travels along straight line *q-q* which is perpendicular to *ED*. The mechanism always satisfies the conditions: $\overline{DA} \times \overline{DB} = a^2 - b^2 = \text{const}$. The polar equation of straight line *q-q* is

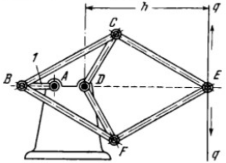
$$\overline{DB} \cos \alpha = \frac{a^2 - b^2}{2\overline{ED}} = \text{const}.$$

Directions *AB* and *CF* are always mutually perpendicular.

703

PEAUCELLIER-LIPKIN EXACT STRAIGHT-LINE MECHANISM

LW
GI



The lengths of the links comply with the conditions: $\overline{BC} = \overline{CE} = \overline{EF} = \overline{FB} = a$, $\overline{DC} = \overline{DF} = b$ and $\overline{AB} = \overline{AD}$. The mechanism always satisfies the condition

$$\overline{DB} \times \overline{DE} = a^2 - b^2 = k^2,$$

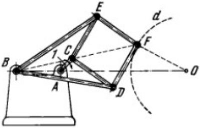
where k is the inversion constant. When crank *1* turns about fixed axis *A*, point *E* travels along straight line *q-q* which is perpendicular to *AD* and is at the distance h from point *D*:

$$h = \frac{k^2}{2\,\overline{AB}}.$$

704

PEAUCELLIER-LIPKIN CIRCLE INVERSION MECHANISM

LW
GI



The lengths of the links comply with the conditions: $\overline{CE} = \overline{CD} = \overline{DF} = \overline{EF} = a$, $\overline{BE} = \overline{BD} = b$ and $\overline{AB} > \overline{AC}$. The mechanism always satisfies the condition

$$\overline{BC} \times \overline{BF} = b^2 - a^2 = k^2$$

where k is the inversion constant. When crank *1* turns about fixed axis A, point F describes circle d which is the inversion of the circle described by point C. Centre O of the circle described by point F lies on the straight line passing through points B and A. Distances $\overline{BA}$ and $\overline{BO}$ are related by the condition

$$\overline{BO} = \overline{BA}\,\frac{k^2}{\overline{BA}^2 - \overline{AC}^2}$$

Radius OF of the circle described by point F equals

$$\overline{OF} = \overline{AC}\,\frac{\overline{BO}}{\overline{BA}}$$

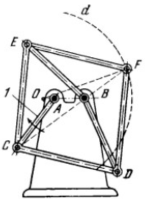
For the specified link length relationships, point F describes only a circular arc within the limits of the angle of turn of crank *1*.

705

PEAUCELLIER-LIPKIN CIRCLE INVERSION MECHANISM

LW

GI



The lengths of the links comply with the conditions: $\overline{CE} = \overline{EF} = \overline{FD} = \overline{DC} = a$, $\overline{BE} = \overline{BD} = b$ and $\overline{AC} > \overline{AB}$. The mechanism always satisfies the inversion condition $BC \times BF = a^2 - b^2 = k^2$, where k is the inversion constant. When crank *1* turns about fixed axis *A*, point *F* describes circle *d* which is the inversion of the circle described by point *C*. Centre *O* of circle *d* lies on the straight line passing through points *A* and *B*. Distances *BA* and *BO* are related by the condition

$$\overline{BO} = \overline{BA}\,\frac{k^2}{\overline{AC}^2 - \overline{BA}^2}$$

Radius $\overline{OF}$ of circle *d* equals

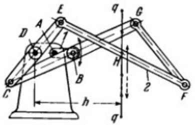
$$\overline{OF} = \overline{AC}\,\frac{\overline{BO}}{\overline{BA}}\ .$$

For the specified link length relationships, point *F* describes a complete circle for one complete revolution of crank *1* about axis *A*.

706

HART EXACT STRAIGHT-LINE MECHANISM

LW
GI



The lengths of the links comply with the conditions: $\overline{EC} = \overline{GF}$, $\overline{EF} = \overline{CG}$, $\overline{DE} = \overline{DC} = a$, $\overline{CB} = \overline{BG} = \overline{EH} = \overline{HF} = b$ and $\overline{AB} = \overline{AD}$. The mechanism always satisfies the inversion condition $DB \times DH = b^2 - a^2 = k^2$, where k is the inversion constant. When crank *1* turns about fixed axis A, point H of link *2* travels along straight line q-q which is perpendicular to base AD and is at the distance h from point D:

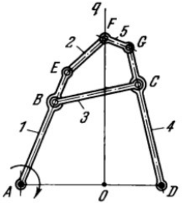
$$h = \frac{k^2}{2\,\overline{AB}} .$$

Figure $EFGC$ forms a crossed-crank linkage.

707

HART EXACT STRAIGHT-LINE MECHANISM

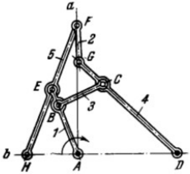
LW
GI



The lengths of the links comply with the conditions: $\overline{BE}=\dfrac{ab^2}{a-b^2}$, $\overline{EF}=\dfrac{cdb}{d^2-b^2}$, $\overline{FG}=\dfrac{adb}{d^2-b^2}$ and $\overline{GC}=\dfrac{cb^2}{d^2-b^2}$, where $a=\overline{AB}$, $b=\overline{BC}$, $c=\overline{CD}$ and $d=\overline{AD}$. Link *1* turns about fixed axis *A* and is connected by turning pairs *B* and *E* to links *3* and *2*. Link *4* turns about fixed axis *D* and is connected by turning pairs *C* and *G* to links *3* and *5*. Links *2* and *5* are connected by turning pair *F*. When link *1* turns about axis *A*, point *F* describes straight line *Oq* which is perpendicular to *AD*. Intersect $\overline{AO}$ equals

$$\overline{AO}=\frac{d}{2}\,\frac{a^2-b^2-c^2+d^2}{d^2-b^2}\,.$$

HART EXACT STRAIGHT-LINE MECHANISM

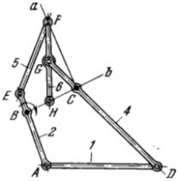


The lengths of the links comply with the conditions: $\overline{AD} = \overline{DC}$, $\overline{AB} = \overline{BC}$, $\overline{AE} = \overline{EF} = \overline{EH}$ and $\overline{CG} = \overline{GF}$. Figure *ABCD* is a rhomboid linkage. Link *1* turns about fixed axis *A* and is connected by turning pairs *B* and *E* to links *3* and *5*. Link *4* turns about fixed axis *D* and is connected by turning pairs *C* and *G* to links *3* and *2*. Links *2* and *5* are connected by turning pair *F*. When link *1* turns about axis *A*, point *F* describes straight line *Aa* which is perpendicular to *AD*, and point *H* describes straight line *Ab* which coincides with *AD*. Points of link *5* describe ellipses. Angle $\angle AEF$ is always equal to angle $\angle FGC$. Angle $\angle FCB$ equals 90°.

709

HART EXACT STRAIGHT-LINE MECHANISM

LW
GI



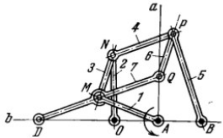
The lengths of the links comply with the conditions: $\overline{AD} = \overline{DC}$, $\overline{AB} = \overline{BC}$, $\overline{AE} = \overline{EF}$ and $\overline{CG} = \overline{GF} = \overline{GH}$. Figure $CDAB$ is a rhomboid linkage. Link *2* turns about fixed axis B and is connected by turning pairs A and E to links *1* and *5*. Link *4* turns about fixed axis C and is connected by turning pairs D and G to links *1* and *6*. Links *5* and *6* are connected by turning pair F. When link *2* turns about axis B, point F describes straight line Ca which is perpendicular to BC, and point H describes straight line Bb which coincides with BC. The points of link *6* describe ellipses. Angle $\angle AEF$ is always equal to angle $\angle FGC$.

710

BRICARD EXACT STRAIGHT-LINE MECHANISM

LW

GI

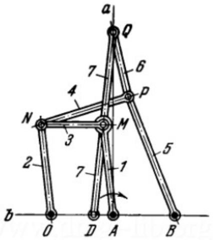


The lengths of the links comply with the conditions: $\overline{OA} = \overline{AB} = \overline{MN} = \overline{QP}$, $\overline{AM} = \overline{PN} = \overline{ON} = \overline{MQ} = \overline{MD} = \overline{OA}\sqrt{2}$ and $BP = 2OA$. Figures *MNPQ*, *ONPB* and *ONMA* are parallel-crank, rhomboid and crossed-crank linkages, respectively. Link *1* turns about fixed axis *A* and is connected by turning pairs *M* to links *3* and *7*. Link *2* turns about fixed axis *O* and is connected by turning pairs *N* to links *3* and *4*. Link *5* turns about fixed axis *B* and is connected by turning pairs *P* to links *4* and *6*. When link *1* turns about axis *A*, point *Q* describes straight line *Aa* which is perpendicular to straight line *OAB* and passes through point *A*. Point *D* describes straight line *Ab* which coincides with line *OAB*. The points of link *7* describe ellipses.

711

BRICARD EXACT STRAIGHT-LINE MECHANISM

LW
GI

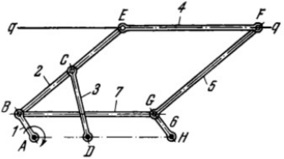


The lengths of the links comply with the conditions: $\overline{OA} = \overline{AB} = \overline{MN} = \overline{QP}$, $\overline{AM} = \overline{PN} = \overline{ON} = \overline{MQ} = \overline{MD} = \overline{OA}\sqrt{2}$ and $\overline{PB} = 2\overline{OA}$. Figures *MNPQ*, *ONPB* and *ONMA* are crossed-crank, rhomboid and parallel-crank linkages, respectively. Link *1* turns about fixed axis *A* and is connected by turning pairs *M* to links *3* and *7*. Link *2* turns about fixed axis *O* and is connected by turning pairs *N* to links *3* and *4*. Link *5* turns about fixed axis *B* and is connected by turning pairs *P* to links *4* and *6*. When link *1* turns about axis *A*, point *Q* describes straight line *Aa* which is perpendicular to straight line *OAB* and passes through point *A*. Point *D* describes straight line *Ab* which coincides with line *OAB*. The points of link *7* describe ellipses.

712

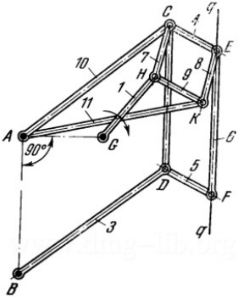
STRAIGHT-LINE MECHANISM HAVING A LINK WITH RECTILINEAR TRANSLATION

LW
GI



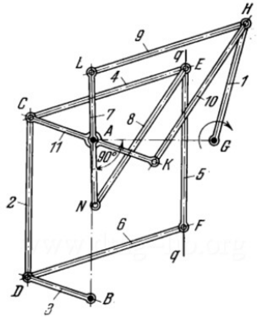
The lengths of the links comply with the conditions: $\overline{AD} = 2\overline{AB}$, $\overline{BC} = \overline{DC} = \overline{CE} = 2.5\overline{AB}$, $\overline{BE} = \overline{GF}$, $\overline{BG} = \overline{EF} = \overline{AH}$ and $\overline{HG} = \overline{AB}$. The mechanism is based on four-bar linkage *ABCD* of which point *E* on connecting rod *2* has approximate rectilinear motion over a certain portion of its path when link *1* turns about fixed axis *A*. This motion approximately coincides with straight line *q-q*, belonging to the fixed link and parallel to *AH*. With links of the specified lengths, figures *ABGH* and *BEFG* are parallel-crank linkages and link *4* has translational motion. During the period of time that point *E* travels along the approximately straight portion of its path, all points of link *4* also travel approximately straight and axis *EF* of link *4* slides along straight line *q-q*. Links *3* and *6* turn about fixed axes *D* and *H*.

STRAIGHT-LINE MECHANISM HAVING A LINK WITH RECTILINEAR TRANSLATION



The lengths of the links comply with the conditions: $\overline{HC} = \overline{CE} = \overline{EK} = \overline{KH} = \overline{DF}$, $\overline{AC} = \overline{AK} = \overline{BD}$, $\overline{EF} = \overline{CD} = \overline{AB}$ and $\overline{GH} = \overline{GA}$. The mechanism is based on the Peaucellier-Lipkin six-bar inversor consisting of rhombus linkage *HCEK* and rhomboid linkage *ACHK* with the centre of inversion at point *A*. Point *H* describes a circle passing through point *A* and point *E* describes straight line *q-q* which is perpendicular to line *AG*. Link *6* is a component of a translator consisting of two parallel-crank linkages, *ACDB* and *CEFD*. When link *1* turns about fixed axis *G*, link *6* has rectilinear translational motion and its axis *EF* slides along straight line *q-q* which belongs to the fixed plane and is parallel to line *AB*. Links *10* and *11* turn about fixed axis *A* and link *3* about fixed axis *B*.

714 STRAIGHT-LINE MECHANISM HAVING A LINK WITH RECTILINEAR TRANSLATION LW GI

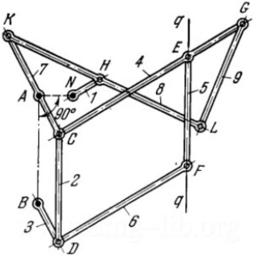


The lengths of the links comply with the conditions: $\overline{LH} = \overline{NE} = \overline{KH} = \overline{CE} = \overline{DF}$, $\overline{AK} = \overline{AC} = \overline{AL} = \overline{AN} = \overline{BD}$, $\overline{HG} = \overline{AG}$ and $\overline{CD} = \overline{EF}$. The mechanism is based on the Perrolatz six-bar inversor consisting of two rhomboid linkages, *ALHK* and *ACEN*, with the centre of inversion at point *A*. Point *H* describes a circle passing through point *A*, and point *E* describes straight line *q*-*q* which is perpendicular to line *AG*. Link *5* is a component of a translator consisting of two parallel-crank linkages *ACDB* and *CEFD*. When link *1* turns about fixed axis *G*, link *5* has rectilinear translational motion and its axis *EF* slides along straight line *q*-*q* which belongs to the fixed plane and is parallel to line *AB*. Links *7* and *11* turn about fixed axis *A* and link *3* about fixed axis *B*.

715

STRAIGHT-LINE MECHANISM HAVING A LINK WITH RECTILINEAR TRANSLATION

LW
GI

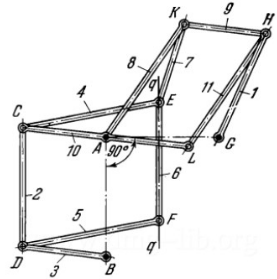


The lengths of the links comply with the conditions: $\overline{KL} = \overline{CG}$, $\overline{KC} = \overline{GL}$, $\overline{AC} = \overline{BD}$, $\overline{EF} = \overline{CD} = \overline{AB}$, $\overline{AN} = \overline{HN}$, $\overline{CE} = \overline{DF}$ and $\overline{AC} : \overline{AK} = \overline{KH} : \overline{CE}$. The mechanism is based on the Hart four-bar inversor, consisting of crossed-crank linkage *CKLG* with the centre of inversion at point *A*. Point *H* describes a circle passing through point *A* and point *E* describes straight line *q-q* which is perpendicular to line *AN*. Link *5* is a component of a translator consisting of two parallel-crank linkages, *ACDB* and *CEFD*. When link *1* turns about fixed axis *N*, link *5* has rectilinear translational motion and its axis *EF* slides along straight line *q-q* which belongs to the fixed plane and is parallel to line *AB*. Link *7* turns about fixed axis *A* and link *3* about fixed axis *B*.

716

STRAIGHT-LINE MECHANISM HAVING A LINK WITH RECTILINEAR TRANSLATION

LW
GI

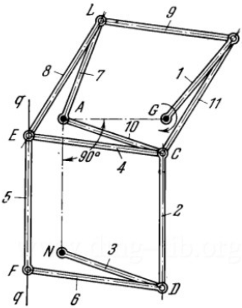


The lengths of the links comply with the conditions: $\overline{AK} = \overline{LH} = \overline{CE} = \overline{DF}$, $\overline{CA} = \overline{AL} = \overline{KH} = \overline{DB}$, $\overline{GH} = \overline{GA}$ and $\overline{CD} = \overline{EF}$. The mechanism is based on the three-bar inversor consisting of crossed-crank linkage *ACEK* and parallel-crank linkage *AKHL* with the centre of inversion at point *A*. Point *H* describes a circle passing through point *A* and point *E* describes straight line *q-q* which is perpendicular to line *AG*. Link *6* is a component of a translator consisting of two parallel-crank linkages, *ACDB* and *CEFD*. When link *1* turns about fixed axis *G*, link *6* has rectilinear translation and its axis *EF* slides along straight line *q-q* which belongs to the fixed plane and is parallel to line *AB*. Links *8* and *10* turn about fixed axis *A* and link *3* about fixed axis *B*.

717

STRAIGHT-LINE MECHANISM HAVING A LINK WITH RECTILINEAR TRANSLATION

LW
GI

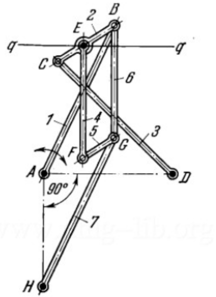


The lengths of the links comply with the conditions: $\overline{EL} = \overline{LK} = \overline{KC} = \overline{CE} = \overline{DF}$, $\overline{AL} = \overline{AC} = \overline{ND}$, $\overline{AG} = \overline{GK}$ and $\overline{CD} = \overline{EF} = \overline{AN}$. The mechanism is based on the Peaucellier-Lipkin six-bar inversor consisting of rhombus linkage *ELKC* and rhomboid linkage *ALKC* with the centre of inversion at point *A*. Point *K* describes a circle passing through point *A* and point *E* describes straight line *q-q* which is perpendicular to line *AG*. Link *5* is a component of a translator consisting of two parallel-crank linkages, *ACDN* and *CDFE*. When link *1* turns about fixed axis *G*, link *5* has rectilinear translation and its axis *EF* slides along straight line *q-q* which belongs to the fixed plane and is parallel to line *AN*. Links *7* and *10* turn about fixed axis *A* and link *3* about fixed axis *N*.

718

APPROXIMATE STRAIGHT-LINE MECHANISM HAVING A LINK WITH RECTILINEAR TRANSLATION

LW
GI



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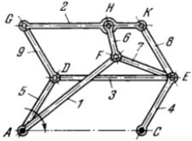
The lengths of the links comply with the conditions: $\overline{AD} = 0.8\overline{AB}$, $\overline{AB} = \overline{DC}$, $\overline{CE} = \overline{EB} = 0.2\,\overline{AB}$, $\overline{EF} = \overline{BG} = \overline{AH}$ and $\overline{FG} = \overline{EB}$. The mechanism is based on four-bar linkage *ABCD*. When link *1* turns about fixed axis *A*, point *E* of connecting rod *2* describes a path of which a certain portion approximates straight line *q-q* which is parallel to line *AD*. For the specified dimensions, figures *EBGF* and *ABGH* form parallel-crank linkages and link *4* has translational motion. During the period of time that point *E* travels along the approximately rectilinear portion of its path, all points of link *4* travel approximately rectilinearly and its axis *EF* is perpendicular to straight line *q-q*. Links *3* and *7* turn about fixed axes *D* and *H*.

719

KEMPE STRAIGHT-LINE MECHANISM HAVING A LINK WITH RECTILINEAR TRANSLATION

LW

GI

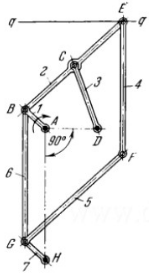


The lengths of the links comply with the conditions: $\overline{AD} = \overline{CE} = \overline{EF} = \overline{EK} = \overline{DG}$, $\overline{AC} = \overline{DE} = \overline{GK} = \overline{AF}$ and $\overline{HK} = \overline{HF}$. Figures *ADEC* and *DGKE* form parallel-crank linkages and figures *AFEC* and *HKEF* form rhomboid linkages. Link *1* turns about fixed axis *A* and is connected by turning pairs *F* to links *6* and *7*. Link *5* turns about fixed axis *A* and is connected by turning pairs *D* to links *3* and *9*. Link *4* turns about fixed axis *C* and is connected by turning pairs *E* to links *3*, *7* and *8*. Link *2* is connected by turning pairs *G*, *H* and *K* to links *9*, *6* and *8*. When link *1* turns about axis *A*, link *2* has rectilinear translation in a direction perpendicular to line *AC*.

720

APPROXIMATE STRAIGHT-LINE MECHANISM HAVING A LINK WITH RECTILINEAR TRANSLATION

LW
G1



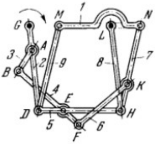
The lengths of the links comply with the conditions: $\overline{AD} = 2\overline{AB}$, $\overline{BC} = \overline{DC} = \overline{CE} = 2.5\overline{AB}$, $\overline{BE} = \overline{GF}$, $\overline{BG} = \overline{EF} = \overline{AH}$ and $\overline{HG} = \overline{AB}$. The mechanism is based on four-bar linkage *ABCD*. When link *1* turns about fixed axis *A*, point *E* of connecting rod *2* describes a path of which a certain portion approximates straight line *q-q*, belonging to the fixed link and parallel to line *AD*. For the specified dimensions, figures *ABGH* and *BEFG* form parallel-crank linkages and link *4* has translational motion. During the period of time that point *E* travels along the approximately rectilinear portion of its path, all points of link *4* also travel approximately rectilinearly and its axis *EF* is perpendicular to straight line *q-q*. Links *3* and *7* turn about fixed axes *D* and *H*.

721

GAGARIN STRAIGHT-LINE MECHANISM HAVING A LINK WITH RECTILINEAR TRANSLATION

LW

GI



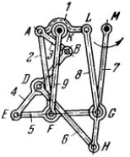
The lengths of the links comply with the conditions: $\overline{GD} = \overline{LH} = \overline{MD} = \overline{NH}$, $\overline{DH} = \overline{MN} = \overline{GL}$, $\overline{AB} = \overline{DE} = \overline{EF} = \overline{HK}$, $\overline{BE} = \overline{AD} = \overline{FK} = \overline{EH}$ and $\overline{BE} = (1 + \sqrt{2})\,\overline{AB}$. Figures *GDHL* and *MDHN* are parallel-crank linkages; figures *ABED* and *EFKH* are crossed-crank linkages. Link *2* turns about fixed axis *G* and is connected by turning pairs *A* and *D* to link *3* and to links *9* and *5*. Link *4* is connected by turning pairs *B*, *E* and *F* to links *3*, *5* and *6*. Link *8* turns about fixed axis *L* and is connected by turning pairs *H* to links *5* and *7*. Link *7* is connected by turning pairs *N* and *K* to links *1* and *6*. Link *9* is connected by turning pair *M* to link *1*. When link *2* turns about axis *G*, link *1* has rectilinear translation in the direction coinciding with line *GL*.

722

GAGARIN STRAIGHT-LINE MECHANISM HAVING A LINK WITH RECTILINEAR TRANSLATION

LW

GI



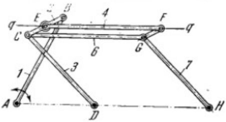
The lengths of the links comply with the conditions: $\overline{KF} = \overline{MG} = \overline{LG} = \overline{AF}$, $\overline{FG} = \overline{AL} = \overline{KM}$, $\overline{AB} = \overline{ED} = \overline{EF} = \overline{GH}$, $\overline{BE} = \overline{DH} = \overline{EG} = \overline{AF}$ and $\overline{BE} = (1 + \sqrt{2})\,\overline{AB}$. Figures *AFGL* and *KFGM* are parallel-crank linkages; figures *ABEF* and *EDHG* are crossed-crank linkages. Link *9* turns about fixed axis *K* and is connected by turning pairs *F* to links *2* and *5*. Link *2* is connected by turning pairs *A* to links *1* and *3*. Link *4* is connected by turning pairs *B*, *D* and *E* to links *3*, *6* and *5*. Link *7* turns about fixed axis *M* and is connected by turning pairs *G* and *H* to links *5*, *8* and *6*. Link *8* is connected by turning pair *L* to link *1*. When link *7* turns about axis *M*, link *1* has rectilinear translation in the direction coinciding with line *KM*.

723

APPROXIMATE STRAIGHT-LINE MECHANISM HAVING A LINK WITH RECTILINEAR TRANSLATION

LW

GI



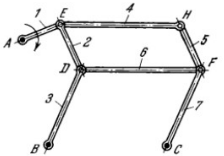
The lengths of the links comply with the conditions: $\overline{AD} = 0.8\overline{AB}$, $\overline{AB} = \overline{DC} = \overline{HG}$, $\overline{CE} = \overline{EB} = \overline{GF} = 0.2\overline{AB}$ and $\overline{EF} = \overline{CG} = \overline{DH}$. The mechanism is based on four-bar linkage *ABCD*. When link *1* turns about fixed axis *A*, point *E* of connecting rod *2* describes a path of which a certain portion approximates straight line *q-q*, belonging to the fixed link and parallel to line *AH*. For the specified dimensions, figures *DCGH* and *CEFG* are parallel-crank linkages and link *4* has translational motion. During the period of time that point *E* travels along the approximately rectilinear portion of its path, all points of link *4* travel approximately rectilinearly and axis *EF* of link *4* slides along straight line *q-q*. Links *3* and *7* turn about fixed axes *D* and *H*.

724

MULTIPLE-BAR MECHANISM WITH A TRANSLATIONAL LINK

LW

GI

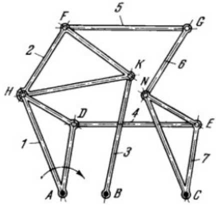


The lengths of the links comply with the conditions: $\overline{BD} = \overline{CF}$, $\overline{ED} = \overline{HF}$ and $\overline{EH} = \overline{DF} = \overline{BC}$. The mechanism is based on a translator consisting of parallel-crank linkages *BDFC* and *DEHF*. Links *3* and *7* turn about fixed axes *B* and *C*. When link *1* turns about fixed axis *A*, link *4* has translational motion and all of its points describe circles of radius $\overline{AE}$.

725

MULTIPLE-BAR MECHANISM WITH A TRANSLATIONAL LINK

LW
GI

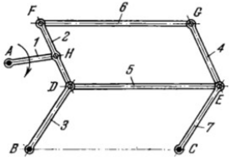


The lengths of the links comply with the conditions: $\overline{AH} = \overline{CN}$, $\overline{HF} = \overline{NG}$, $\overline{FG} = \overline{DE} = \overline{AC}$, $\overline{HD} = \overline{NE}$ and $\overline{AD} = \overline{CE}$. The mechanism is based on a translator consisting of parallel-crank linkages *ADEC* and *HFGN*. Links *3* and *7* turn about fixed axes *B* and *C*. When link *1* turns about fixed axis *A*, link *5* has translational motion and all of its points describe the same connecting-rod curve that is described by point *F* of connecting rod *2* in four-bar linkage *AHKB*.

726

MULTIPLE-BAR MECHANISM WITH A TRANSLATIONAL LINK

LW
GI



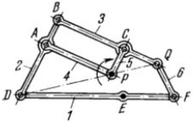
The lengths of the links comply with the conditions: $\overline{BD} = \overline{CE}$, $\overline{FG} = \overline{DE} = \overline{BC}$ and $\overline{DF} = \overline{EG}$. The mechanism is based on a translator consisting of parallel-crank linkages *BDEC* and *DFGE*. Links *3* and *7* turn about fixed axes *B* and *C*. When link *1* turns about fixed axis *A*, link *6* has translational motion and all of its points describe connecting-rod curves identical to the curve described by point *F* of connecting rod *2* in the four-bar linkage *AHDB*.

727

MULTIPLE-BAR MECHANISM WITH A TRANSLATIONAL LINK

LW

GI



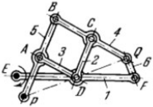
The lengths of the links comply with the conditions: $\overline{AB} = \overline{PC}$, $\overline{BC} = \overline{AP}$ and $\overline{DB} : \overline{BQ} = \overline{DA} : \overline{AP} = \overline{PC} : \overline{CQ}$. Figure $ABCP$ is a parallel-crank linkage and points D, P and Q lie on a single straight line. Line QF of link 6 should be parallel to line PE. Links 4 and 5 turn about fixed axis P and are connected by turning pairs A and C to links 2 and 3. Link 1 turns about fixed axis E and is connected by turning pairs D and F to links 2 and 6. Link 3 is connected by turning pairs B and Q to links 2 and 6. When link 5 turns about fixed axis P, link 6 has translational motion and all of its points describe circles of radius $\overline{EF}$.

728

DELONÉ MULTIPLE-BAR MECHANISM WITH A TRANSLATIONAL LINK

LW

GI



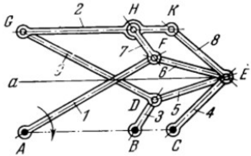
The lengths of the links comply with the condition: $\overline{AB} = \overline{BC} = \overline{CD} = \overline{DA} = \overline{PA} = \overline{CQ}$. Figure $ABCD$ is a rhombus linkage and points P, D and Q lie on a single straight line. Line QF of link 6 should be parallel to line EP. Link 1 turns about fixed axis E and is connected by turning pairs D to links 2 and 3 and by turning pair F to link 6. Link 5 turns about fixed axis P and is connected by turning pairs A and B to links 3 and 4. Link 4 is connected by turning pairs C and Q to links 2 and 6. When link 1 turns about fixed axis E, link 6 has translational motion and all of its points describe circles of radius $\overline{EF}$.

729

KEMPE STRAIGHT-LINE MECHANISM HAVING A LINK WITH RECTILINEAR TRANSLATION

LW

GI

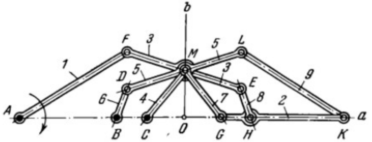


The lengths of the links comply with the conditions: $\overline{AF} = \overline{AC} = \overline{GK} = \overline{GD}$, $\overline{EC} = \overline{ED} = \overline{EK} = \overline{EF} = \frac{\overline{AC}}{2}$ and $\overline{HK} = \overline{HF} = \overline{BC} = \overline{BD} = \frac{\overline{CE}}{2}$. Figures *GKED*, *AFEC*, *HKEF* and *BDEC* are rhomboid linkages. Axis *Ea*, parallel to straight line *ABC*, is the axis of mirror symmetry of the upper and lower halves of the mechanism. Link *1* turns about fixed axis *A* and is connected by turning pairs *F* to links *6* and *7*. Link *3* turns about fixed axis *B* and is connected by turning pairs *D* to links *5* and *9*. Links *5*, *6* and *8* are connected by turning pairs *E* to link *4* which turns about fixed axis *C*. Link *2* is connected by turning pairs *G*, *H* and *K* to links *9*, *7* and *8*. When link *1* turns about axis *A*, link *2* has rectilinear translation in a direction perpendicular to line *ABC*.

730

KEMPE STRAIGHT-LINE MECHANISM HAVING A LINK WITH RECTILINEAR TRANSLATION

LW
GI

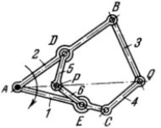


The lengths of the links comply with the conditions: $\overline{AF} = \overline{AC} = \overline{KL} = \overline{KG}$, $\overline{MF} = \overline{MC} = \overline{ME} = \overline{ML} = \overline{MG} = \overline{MD}$ and $\overline{BD} = \overline{BC} = \overline{GH} = \overline{HE}$. Figures $AFMC$, $BDMC$, $MLKG$ and $MEHG$ are rhomboid linkages. Points A, B, C, G, H and K lie on single straight line Oa. Axis Ob, perpendicular to straight line Oa and passing through point M, is the axis of mirror symmetry of the left and right halves of the mechanism. Link *1* turns about fixed axis A and is connected by turning pair F to link *3*. Link *6* turns about fixed axis B and is connected by turning pair D to link *5*. Link *4* turns about fixed axis C and is connected by turning pair M to link *3*. Links *3*, *5* and *7* are connected together by turning pair M and by turning pairs E, L and G to links *8*, *9* and *2*. Link *2* is connected by turning pairs K and H to links *9* and *8*. When link *1* turns about axis A, link *2* has rectilinear translation along line Oa.

731

MULTIPLE-BAR INVERSOR MECHANISM

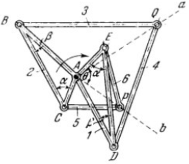
LW
GI



The lengths of the links comply with the conditions: $\overline{AB} : \overline{AD} = \overline{BQ} : \overline{DP}$ and $\overline{AC} : \overline{AE} = \overline{CQ} : \overline{EP}$. Links *1* and *2* turn about fixed axis *A* which is the centre of inversion transformation. Links *3* and *4* are connected together by turning pair *Q*, and by turning pairs *B* and *C* to links *2* and *1*. Links *5* and *6* are connected together by turning pair *P*, and by turning pairs *D* and *E* to links *2* and *1*. For any configuration of the mechanism, points *A*, *P* and *Q* lie on a single straight line. When point *P* or *Q* travels along any arbitrary curve, the other point describes a curve which is the inversion of the first curve. Hence, the mechanism accomplishes inversion transformations of the form

$$\overline{AP} \times \overline{AQ} = \overline{AB} \times \overline{AD} - \overline{DP} \times \overline{BQ} = \overline{AC} \times \overline{AE} - \overline{EP} \times \overline{CQ} = \text{const.}$$

MULTIPLE-BAR INVERSOR MECHANISM



The lengths of the links comply with the conditions: $\overline{AC} : \overline{AB} = \overline{CP} : \overline{BQ}$, $\overline{AE} : \overline{AD} = \overline{EP} : \overline{DQ}$ and $\theta = \alpha + \beta$. Links *1* and *2* turn about fixed axis *A* which is the centre of inversion transformation. Links *3* and *5* are connected by turning pairs *B* and *C* to link *2* and by turning pairs *Q* and *P* to links *4* and *6*. Links *4* and *6* are connected by turning pairs *D* and *E* to link *1*. When point *P* or *Q* travels along any arbitrary curve, the other point describes a curve which is the inversion of the first curve. Hence, the mechanism accomplishes inversion transformations of the form

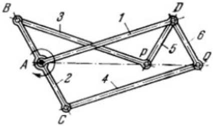
$$\overline{AP} \times \overline{AQ} = \overline{BQ} \times \overline{CP} = \overline{AB} \times \overline{AC} = \overline{DQ} \times \overline{EP} = \overline{AD} \times \overline{AE} = \text{const}.$$

733

MULTIPLE-BAR INVERSOR MECHANISM WITH PARALLEL- AND CROSSED-CRANK LINKAGES

LW

GI

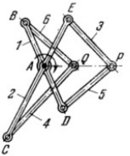


The lengths of the links comply with the conditions: $\overline{AB} = \overline{AC} = \overline{DP} = \overline{DQ} = a$ and $\overline{AD} = \overline{BP} = \overline{CQ} = b$. Figure $ABPD$ is a crossed-crank linkage and figure $ADQC$ is a parallel-crank linkage. Links *1* and *2* turn about fixed axis A which is the centre of inversion transformation. Links *3* and *4* are connected by turning pairs B and C to link *2* and by turning pairs P and Q to links *5* and *6*. Links *5* and *6* are connected by turning pairs D to each other and to link *1*. For any configuration of the mechanism, points A, P and Q lie on a single straight line. When point P or Q travels along any arbitrary curve, the other point describes a curve which is the inversion of the first curve. Hence, the mechanism accomplishes inversion transformations of the form

$$\overline{AP} \times \overline{AQ} = b^2 - a^2 = \text{const}.$$

734 MULTIPLE-BAR INVERSOR MECHANISM

LW
GI



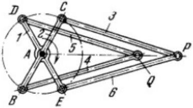
The lengths of the links comply with the conditions: $\overline{AC} : \overline{AE} = \overline{CQ} : \overline{EP}$ and $\overline{AB} : \overline{AD} = \overline{BQ} : \overline{DP}$. Links *1* and *2* turn about fixed axis *A* which is the centre of inversion transformation. Links *3* and *4* are connected by turning pairs *E* and *C* to link *2* and by turning pairs *P* and *Q* to links *5* and *6*. Links *5* and *6* are connected by turning pairs *D* and *B* to link *1*. For any configuration of the mechanism, points *P*, *Q* and *A* lie on a single straight line. When point *P* or *Q* travels along any arbitrary curve, the other point describes a curve which is the inversion of the first curve. Hence, the mechanism accomplishes inversion transformations of the form

$$\overline{AP} \times \overline{AQ} = \overline{CQ} \times \overline{EP} - \overline{AC} \times \overline{AE} = \overline{BQ} \times \overline{DP} - \overline{AD} \times \overline{AB} = \text{const.}$$

735

PERROLATZ MULTIPLE-BAR INVERSOR MECHANISM

LW
GI

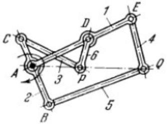


The lengths of the links comply with the conditions: $\overline{AB} = \overline{AC} = \overline{AD} = \overline{AE} = b$ and $\overline{CP} = \overline{DQ} = \overline{BQ} = \overline{EP} = a$. Links 1 and 2 turn about fixed axis A which is the centre of inversion transformation. Links 3 and 4 are connected by turning pairs C and B to link 2 and by turning pairs P and Q to links 6 and 5. Links 6 and 5 are connected by turning pairs E and D to link 1. For any configuration of the mechanism, points A, Q and P lie on a single straight line. When point P or Q travels along any arbitrary curve, the other point describes a curve which is the inversion of the first curve. Hence, the mechanism accomplishes inversion transformations of the form

$$\overline{AP} \times \overline{AQ} = b^2 - a^2 = \text{const.}$$

736 MULTIPLE-BAR INVERSOR MECHANISM

LW
GI



The lengths of the links comply with the conditions: $\overline{AB} : \overline{AC} = \overline{BQ} : \overline{CP}$ and $\overline{AE} : \overline{AD} = \overline{EQ} : \overline{DP}$. Links *1* and *2* turn about fixed axis A which is the centre of inversion transformation. Links *3* and *5* are connected by turning pairs C and B to link *2* and by turning pairs P and Q to links *6* and *4*. Links *6* and *4* are connected by turning pairs D and E to link *1*. For any configuration of the mechanism, points A, P and Q lie on a single straight line. When point P or Q travels along any arbitrary curve, the other point describes a curve which is the inversion of the first curve. Hence, the mechanism accomplishes inversion transformations of the form

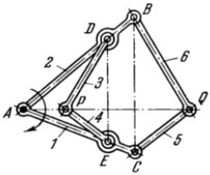
$$\overline{AP} \times \overline{AQ} = \overline{BQ} \times \overline{CP} - \overline{AB} \times \overline{AC} = \overline{AE} \times \overline{AD} - \overline{EQ} \times \overline{DP}.$$

737

MULTIPLE-BAR INVERSOR MECHANISM ACCOMPLISHING TRANSLATION OF TWO STRAIGHT LINES PERPENDICULAR TO THE INVERSOR AXIS

LW

GI



The lengths of the links comply with the conditions: $\overline{AB} : \overline{AD} = \overline{BQ} : \overline{DP}$, $\overline{AC} : \overline{AE} = \overline{CQ} : \overline{EP}$, $\overline{AB}^2 + \overline{CQ}^2 = \overline{AC}^2 + \overline{BQ}^2$ and $\overline{AD}^2 + \overline{EP}^2 = \overline{AE}^2 + \overline{DP}^2$. Links *1* and *2* turn about fixed axis *A* which is the centre of inversion transformation. Link *3* is connected by turning pairs *D* and *P* to links *2* and *4*. Link *4* is connected by turning pair *E* to link *1*. Link *5* is connected by turning pairs *C* and *Q* to links *1* and *6*. Link *6* is connected by turning pair *B* to link *2*. For any configuration of the mechanism, points *A*, *P* and *Q* lie on a single straight line. When point *P* or *Q* travels along any arbitrary curve, the other point describes a curve which is the inversion of the first curve. Hence, the mechanism accomplishes inversion transformations of the form

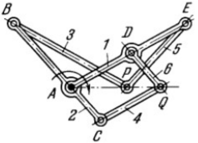
$$\overline{AP} \times \overline{AQ} = \overline{DP} \times \overline{BQ} - \overline{AB} \times \overline{AD} = \overline{AC} \times \overline{AE} - \overline{EP} \times \overline{CQ} = \text{const.}$$

For the specified link length relationships, the mechanism also accomplishes translation displacement of parallel straight lines *DE* and *BC* which are perpendicular to straight line *APQ*.

738

MULTIPLE-BAR INVERSOR MECHANISM

LW
GI



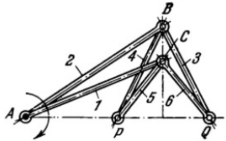
The lengths of the links comply with the conditions: $\overline{AB} : \overline{AC} = \overline{BP} : \overline{CQ}$ and $\overline{AE} : \overline{AD} = \overline{EP} : \overline{DQ}$. Links *1* and *2* turn about fixed axis *A* which is the centre of inversion transformation. Links *3* and *4* are connected by turning pairs *B* and *C* to link *2* and by turning pairs *P* and *Q* to links *5* and *6*. Links *5* and *6* are connected by turning pairs *E* and *D* to link *1*. For any configuration of the mechanism, points *A*, *P* and *Q* lie on a single straight line. When point *P* or *Q* travels along any arbitrary curve, the other point describes a curve which is the inversion of the first curve. Hence, the mechanism accomplishes inversion transformations of the form

$$\overline{AP} \times \overline{AQ} = \overline{BP} \times \overline{CQ} - \overline{AC} \times \overline{AB} = \overline{AE} \times \overline{AD} - \overline{EP} \times \overline{DQ} = \text{const.}$$

739

MULTIPLE-BAR INVERSOR MECHANISM WITH A RHOMBOID LINKAGE

LW
GI



The lengths of the links comply with the conditions: $\overline{BP} = \overline{BQ}$ and $\overline{CP} = \overline{CQ}$. Figure *BQCP* is a rhomboid linkage. Links *1* and *2* turn about fixed axis *A* which is the centre of inversion transformation. Links *4* and *3* are connected by turning pairs *B* to each other and to link *2*, and by turning pairs *P* and *Q* to links *5* and *6*. Links *5* and *6* are connected by turning pairs *C* to each other and to link *1*. For any configuration of the mechanism, points *A*, *P* and *Q* lie on a single straight line. When point *P* or *Q* travels along any arbitrary curve, the other point describes a curve which is the inversion of the first curve. Thus, the mechanism accomplishes inversion transformations of the form

$$\overline{AP} \times \overline{AQ} = \overline{AB}^2 - \overline{BP}^2 = \overline{AC}^2 - \overline{CP}^2 = \text{const.}$$

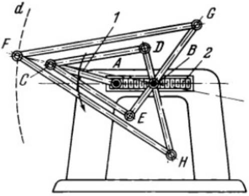
The mechanism also accomplishes translational displacement of straight line *BC* which is perpendicular to straight line *APQ*.

740

MULTIPLE-BAR ADJUSTABLE INVERSOR MECHANISM

LW

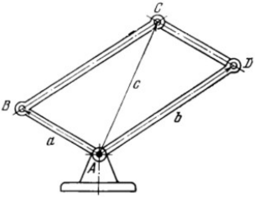
GI



The lengths of the links comply with the conditions: $\overline{FG} = \overline{FH} = q$, $\overline{CD} = \overline{CE} = p$, $\overline{BD} = \overline{BE} = m$ and $\overline{BG} = \overline{BH} = l$. The mechanism always complies with the supplementary conditions: $\frac{m}{l} = \frac{p}{q}$ and $\overline{BC} \times \overline{BF} = pq - ml = k^2$, where k is the inversion constant. When crank *1* turns about fixed axis *A*, point *F* describes circle *d* which is the inversion of the circle described by point *C*. The centre of circle *d* lies on the straight line through points *A* and *B*. The radius of the circle can be changed by turning screw *2* to move the sliding member on which axis *A* is secured, thereby changing distance $\overline{AB}$. If distance $\overline{AB}$ is made equal to $\overline{AC}$, then circle *d* is transformed into a straight line perpendicular to line $\overline{AB}$.

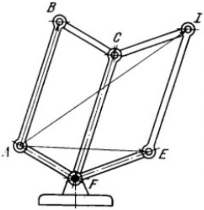
8. MECHANISMS FOR MATHEMATICAL OPERATIONS
(741 through 745)

741	**PARALLEL-CRANK LINKAGE MECHANISM FOR ADDING TWO VECTORS OF CONSTANT MAGNITUDE**	LW MO



The lengths of the links comply with the conditions: $\overline{AB} = \overline{DC}$ and $\overline{BC} = \overline{AD}$. The mechanism constitutes parallel-crank linkage $ABCD$ of which two adjacent sides represent the vectors to be added and the corresponding diagonal represents the resultant vector. Thus $\mathbf{a} + \mathbf{b} = \mathbf{c}$.

742	**MULTIPLE-BAR TRANSLATOR FOR ADDING ONE ARBITRARY AND ONE CONSTANT VECTOR**	LW MO



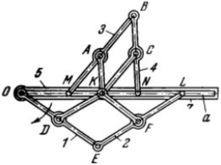
The lengths of the links comply with the conditions: $\overline{AF} = \overline{BC}$, $\overline{FE} = \overline{CD}$ and $\overline{AB} = \overline{FC} = \overline{ED}$. The mechanism is a translator in which side AB represents, in a certain scale, the constant component vector and length $\overline{AE}$ represents the arbitrarily given vector in the same scale. Then, also in the same scale, diagonal AD represents the resultant vector of the first two.

743

MULTIPLE-BAR MECHANISM FOR ADDING TWO LENGTHS HAVING A COMMON DIRECTION

LW

MO



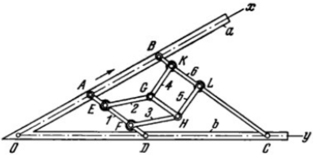
The lengths of the links comply with the conditions: $\overline{OD} = \overline{DE} = \overline{KF}$, $\overline{LF} = \overline{FE} = \overline{KD}$, $\overline{MA} = \overline{AB} = \overline{KC}$ and $\overline{NC} = \overline{CB} = \overline{KA}$. Figures *ABCK* and *FEDK* are parallel-crank linkages. Pins *M*, *K*, *N* and *L* slide along fixed guide *a*. When link *1* turns about fixed axis *O*, the condition $\overline{OL} = \overline{OM} + \overline{ON}$ is always complied with. Thus, the mechanism adds two lengths: $\overline{OM}$ and $\overline{ON}$.

744

MULTIPLE-BAR MECHANISM FOR PLOTTING PROPORTIONAL INTERCEPTS ON COORDINATE AXES

LW

MO



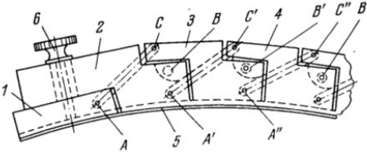
The lengths of the links comply with the conditions: $\overline{EF}=\overline{GH}=\overline{KL}$, $\overline{EG}=\overline{FH}$ and $\overline{GK}=\overline{KL}$. Pins A and D of link *1* and pins B and C of link *6* slide along fixed guides a and b. Links *1* and *6* are connected by a kinematic chain consisting of two parallel-crank linkages, $EGHF$ and $GKLH$. Always complied with in the mechanism is the condition of proportionality of the intercepts indicated on axes Ox and Oy by points A, B, C and D. Thus

$$\frac{\overline{OA}}{\overline{OB}}=\frac{\overline{OD}}{\overline{OC}}.$$

745

CHEBYSHEV ADJUSTABLE ARC CURVE RULER

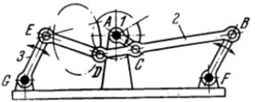
LW
MO



The mechanism is used to draw circular arcs of small curvature. When link *2* is adjusted along link *1*, which is permitted by the difference in diameter between the hole for, and the stem of, screw *6*, all the links change their position so that the distance between hinges, $\overline{BB'}$, $\overline{B'B''}$, $\overline{B''B'''}$, . . ., remains constant, distances $\overline{CC'}$, $\overline{C'C''}$, . . ., increase and distances $\overline{AA'}$, $\overline{A'A''}$, . . ., are reduced. Hence, the ruler is bent to the required arc and screw *6* holds it in this position.

746 MULTIPLE-BAR DWELL MECHANISM

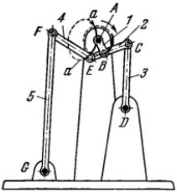
LW
D



The lengths of the links comply with the conditions: $\overline{CB} = 4.3\overline{AC}$, $\overline{BD} = 5.85\overline{AC}$, $\overline{BF} = \overline{EG} = 2.12\overline{AC}$, $\overline{ED} = 2.46\overline{AC}$, $\overline{GF} = 8\overline{AC}$ and $\overline{AG} = \overline{AF} = 4.45\overline{AC}$. When point *C* of crank *1* travels along the part of the circle indicated by a heavy continuous line, point *D* of connecting rod *2* describes a path of which the portion shown by a heavy continuous line approximates a circular arc of radius $\overline{ED}$ with its centre at point *E*. In continuous rotation of crank *1*, link *3* oscillates about fixed axis *G* with a dwell during the time that point *D* travels along the portion of its path indicated by the heavy continuous line.

747 MULTIPLE-BAR DWELL MECHANISM

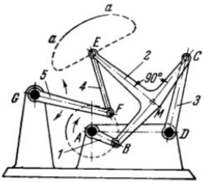
LW
D



The lengths of the links comply with the conditions: $\overline{BC} = 2\overline{AB}$, $\overline{DC} = 5.2\overline{AB}$, $\overline{EC} = 3.6\overline{AB}$, $\overline{EF} = 3.6\overline{AB}$, $\overline{GF} = 11.4\overline{AB}$, $\overline{AD} = 6\overline{AB}$, $\overline{GD} = 8.4\overline{AB}$ and $\overline{AG} = 11\overline{AB}$. Link *4* is connected by turning pairs *E* and *F* to link *2* of four-bar linkage *ABCD* and to link *5* which oscillates about fixed axis *G*. When point *B* of crank *1* travels along the part of the circle indicated by a heavy continuous line, point *E* of connecting rod *2* describes a path of which portion *a*-*a* approximates a circular arc of radius $\overline{FE}$ with its centre at point *F*. During this period link *5* almost ceases to oscillate, i.e. it practically has a dwell.

748 MULTIPLE-BAR DWELL MECHANISM

LW
D



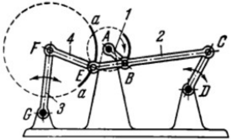
The lengths of the links comply with the conditions: $\overline{BC} = 4.22\overline{AB}$, $\overline{DC} = \overline{GF} = \overline{EM} = 3\overline{AB}$, $\overline{EF} = 2.33\overline{AB}$, $\overline{AD} = 3\overline{AB}$, $\overline{GD} = 5.44\overline{AB}$, $\overline{BM} = \overline{MC}$ and $\overline{AG} = 2.4\overline{AB}$. Link *4* is connected by turning pairs *E* and *F* to connecting rod *2* of four-bar linkage *ABCD* and to link *5* which oscillates about fixed axis *G*. When point *B* of crank *1* travels along the part of the circle indicated by a heavy continuous line, point *E* of connecting rod *2* describes a path of which portion *a-a* approximates a circular arc with its centre at point *F*. During this period link *5* almost ceases to oscillate, i.e. it practically has a dwell.

749

MULTIPLE-BAR DWELL MECHANISM

LW

D



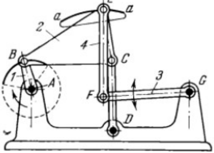
The lengths of the links comply with the conditions: $\overline{BC} = 3.75\overline{AB}$, $\overline{BE} = 1.5\overline{AB}$, $\overline{EF} = 2.12\overline{AB}$, $\overline{GF} = 2.8\overline{AB}$, $\overline{GD} = 6.65\overline{AB}$ and $\overline{GA} = \overline{AD} = 4\overline{AB}$. Link *4* is connected by turning pairs *E* and *F* to connecting rod *2* of four-bar linkage *ABCD* and to link *3* which oscillates about fixed axis *G*. When point *B* of crank *1* travels along the part of the circle indicated by a heavy continuous line, point *E* of connecting rod *2* describes a path of which portion *a-a* approximates a circular arc with its centre at point *F*. During this period link *3* almost ceases to oscillate, i.e. it practically has a dwell.

750

MULTIPLE-BAR DWELL MECHANISM

LW

D



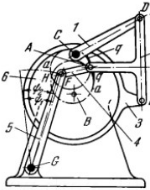
The lengths of the links comply with the conditions: $\overline{BC} = \overline{EF} = \overline{GF} = 3.1\overline{AB}$, $\overline{BE} = 3.5\overline{AB}$, $\overline{CE} = 1.9\overline{AB}$, $\overline{DC} = 2.5\overline{AB}$, $\overline{AD} = 3.3\overline{AB}$, $\overline{AG} = 5.8\overline{AB}$ and $\overline{DG} = 3.1\overline{AB}$. Link *4* is connected by turning pairs *E* and *F* to link *2* of four-bar linkage *ABCD* and to link *3* which oscillates about fixed axis *G*. When point *B* of crank *1* travels along the part of the circle indicated by a heavy continuous line, point *E* of connecting rod *2* describes a path of which portion *a*-*a* approximates a circular arc with its centre at point *F*. During this period link *3* almost ceases to oscillate, i.e. it practically has a dwell.

751

MULTIPLE-BAR MECHANISM WITH DOUBLE OSCILLATION AND A SINGLE DWELL OF THE DRIVEN LINK

LW

D



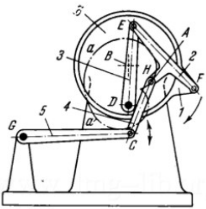
The lengths of the links comply with the conditions: $\overline{DE} = 1.2\overline{BE}$, $\overline{CD} = 1.07\overline{BE}$, $\overline{AF} = 0.44\overline{BE}$, $\overline{GF} = 1.4\overline{BE}$, $\overline{GB} = 1.22\overline{BE}$, $\overline{GC} = 1.75\overline{BE}$, $\overline{BC} = 0.59\overline{BE}$, $\overline{AD} = 1.02\overline{BE}$ and $\overline{AE} = 0.89\overline{BE}$. Link *4* is connected by turning pair *F* to rocker arm *5*, which oscillates about fixed axis *G*, and by turning pair *A* to connecting rod *2* of four-bar drag-link linkage *BEDC*. Crank *3* is designed as a collar that encircles fixed round disk *6* having its centre at point *B*. Point *A* of connecting rod *2* describes curve *a-a* which is self-intersecting at point *H*. Portion *q-q* of this curve, indicated by a heavy continuous line, approximates a circular arc of a radius equal to length $\overline{FA}$ of link *4*, and with its centre at point *F*. When point *A* travels along portion *q-q* of its path, rocker arm *5* is almost stationary, i.e. it practically has a dwell. One revolution of cranks *1* and *3* corresponds to two full oscillations (back and forth) of rocker arm *5* through the angles ψ_1 and ψ_2 with a single dwell at the extreme right-hand position.

752

MULTIPLE-BAR SHORT-DWELL MECHANISM

LW

D



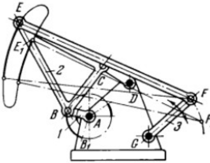
The lengths of the links comply with the conditions: $\overline{FE} = 1.25\overline{BF}$, $\overline{DE} = 1.13\overline{BF}$, $\overline{EH} = 0.85\overline{BF}$, $\overline{HF} = 0.65\overline{BF}$, $\overline{CH} = 0.81\overline{BF}$, $\overline{GC} = 1.56\overline{BF}$, $\overline{BD} = 0.58\overline{BF}$, $\overline{BG} = 1.85\overline{BF}$ and $\overline{GD} = 1.6\overline{BF}$. Link *4* is connected by turning pair *A* to connecting rod *2* of four-bar drag-link linkage *BFED*, and by turning pair *C* to link *5* which turns about fixed axis *G*. Crank *1* is designed as a collar that encircles fixed round disk *6* having its centre at point *B*. Point *A* of connecting rod *2* describes connecting-rod curve *a-a* which has double point *H*. When crank *1* rotates, link *5* has a short dwell at the moment that point *A* of connecting rod *2* coincides with double point *H* of its path.

753

MULTIPLE-BAR TWO-DWELL MECHANISM

LW

D



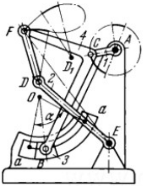
The lengths of the links comply with the conditions: $\overline{BC} = 2.52\overline{AB}$, $\overline{DC} = 1.44\overline{AB}$, $\overline{BE} = 4.44\overline{AB}$, $\overline{CE} = 4.23\overline{AB}$, $\overline{EF} = 8.45\overline{AB}$, $\overline{GF} = 2.52\overline{AB}$, $\overline{AD} = 2.35\overline{AB}$, $\overline{AG} = 2.77\overline{AB}$ and $\overline{DG} = 2.48\overline{AB}$. When point B of crank *1* travels along the portions of the circle indicated by heavy continuous lines, point E of connecting rod *2* describes a path of which the portions shown by heavy continuous lines approximate circular arcs of radius $\overline{FE}$ with centres at points F and F_1. When crank *1* rotates, link *3* oscillates about fixed axis G and has two dwells when point E is on the portions of its path indicated by heavy continuous lines.

754

MULTIPLE-BAR TWO-DWELL MECHANISM

LW

D



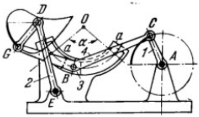
The lengths of the links comply with the conditions: $\overline{CB} = 4.3\overline{AC}$, $\overline{CF} = 2.65\overline{AC}$, $\overline{FD} = 2.1\overline{AC}$, $\overline{DE} = 3.5\overline{AC} = \overline{AE}$, $\overline{OB} = 2\overline{AC}$, $\overline{AO} = 3.6\overline{AC}$, $\overline{EO} = 3.3\overline{AC}$ and $\overline{FB} = 4.86\overline{AC}$. Sliding member *3* slides along guide *a-a* of radius $\overline{OB}$, turning through angle α about axis O. When point C of crank *1* travels along the portions of the circle indicated by heavy continuous lines, point F of connecting rod *4* describes a path of which the portions indicated by heavy continuous lines approximate circular arcs of radius $\overline{DF}$. The centres of the arcs are at points D and D_1. When crank *1* rotates, link *2* oscillates about fixed axis E and has two dwells when point F is on the portions of its path indicated by heavy continuous lines.

755

MULTIPLE-BAR DWELL MECHANISM

LW

D



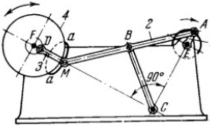
The lengths of the links comply with the conditions: $\overline{CB} = 2.68\overline{AC}$, $\overline{OB} = 1.91\overline{AC}$, $\overline{DG} = \overline{AC}$, $\overline{ED} = 2.32\overline{AC}$, $\overline{AO} = 2.82\overline{AC}$, $\overline{OE} = 2.38\ \overline{AC}$, $\overline{AE} = 3.64\overline{AC}$, $\overline{BG} = 1.86\overline{AC}$ and $\overline{CG} = 4.2\ \overline{AC}$. Sliding member *3* slides along guide *a-a* of radius $\overline{OB}$, turning through angle α about axis O. When point C of crank *1* travels along the portion of the circle indicated by a heavy continuous line, point G of connecting rod *4* describes a path of which a portion approximates a circular arc of radius $\overline{DG}$ (indicated by a heavy continuous line) with its centre at point D. When crank *1* rotates about fixed point A, link *2* oscillates about fixed axis E and has a dwell when point G is on the portion of its path indicated by a heavy continuous line.

756

CHEBYSHEV REVERSING AND DWELL MECHANISM

LW

D

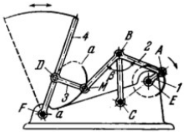


The lengths of the links comply with the conditions: $\overline{AB} = \overline{CB} = \overline{BM} = 1$, $\overline{EA} = 0.19$, $\overline{CE} = 1.11$, $\overline{MD} = 0.403$, $\overline{FD} = 0.12$ and $\overline{CF} = 2.05$. Point M of connecting rod *2* in four-bar linkage $EABC$ describes connecting-rod curve *a-a* of which the portion shown by a heavy continuous line approximates a circular arc of radius $\overline{DM}$ with its centre at point D. When point M travels along this portion, link *4*, designed as a flywheel, remains almost stationary, i.e. it practically has a dwell. At one of the extreme positions (dead points) of the mechanism (shown in the drawing), points F, D and M lie on a single straight line. From this position, flywheel *4* can begin rotating either clockwise or counterclockwise. Consequently, one revolution of crank *1* corresponds to one revolution of flywheel *4* in the same direction and with a prolonged dwell, or to one revolution in the opposite direction with no dwell.

757

CHEBYSHEV MULTIPLE-BAR LONG-DWELL MECHANISM

LW
D

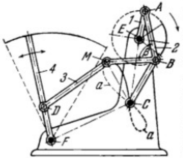


The lengths of the links comply with the conditions: $\overline{AB} = \overline{CB} = \overline{BM} = 1$, $\overline{EA} = 0.305$, $\overline{CE} = 0.76$, $\beta = 114°$, $\overline{MD} = 0.66$, $\overline{FD} = 0.8$, $\overline{CF} = 1.66$ and $\overline{EF} = 2.36$. Point M of connecting rod *2* in four-bar linkage $EABC$ describes connecting-rod curve *a-a* of which a certain portion, shown by a heavy continuous line, approximates a circular arc of radius $\overline{DM}$ (link *3*) with its centre at point D. When point M is on this portion of path *a-a*, link *4* is almost stationary, i.e. it practically has a dwell at one extreme position. The length of the dwell is approximately equal to one half-revolution of crank *1*.

758

CHEBYSHEV MULTIPLE-BAR DWELL MECHANISM

LW
D

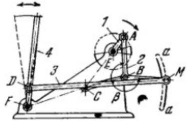


The lengths of the links comply with the conditions: $\overline{AB} = \overline{CB} = \overline{BM} = 1$, $\overline{EA} = 0.54$, $\overline{CE} = 1.3$, $\beta = 80°$, $\overline{MD} = 1.603$, $\overline{FD} = 0.695$, $\overline{CF} = 1.8$ and $\overline{EF} = 2.78$. Point M of connecting rod *2* in four-bar linkage $EABC$ describes connecting-rod curve *a-a* which is self-intersecting at point C. The portion of this curve shown by a heavy continuous line approximates a circular arc of radius $\overline{DM}$ with its centre at point D. When point M is on this portion of path *a-a*, link *4* is almost stationary, i.e. it practically has a dwell at a certain intermediate position. The return stroke of link *4* has no dwell.

759

CHEBYSHEV MULTIPLE-BAR TWO-DWELL MECHANISM

LW
D



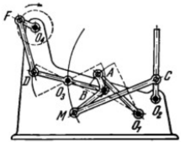
The lengths of the links comply with the conditions: $\overline{AB} = \overline{CB} = \overline{BM} = 1$, $\overline{AE} = 0.43$, $\overline{CE} = 1.15$, $\beta = 265°$, $\overline{MD} = 3.34$, $\overline{FD} = 0.41$, $\overline{CF} = 1.47$ and $\overline{EF} = 2.51$. Point M of connecting rod *2* in four-bar linkage $EABC$ describes connecting-rod curve *a-a* of which two portions, shown by heavy continuous lines, approximate circular arcs of radius $\overline{DM}$ (link *3*) and with their centres at point D. When point M is on these portions of path *a-a*, link *4* is almost stationary, i.e. it practically has two dwells at its extreme positions.

760

CHEBYSHEV NONSYMMETRIC CIRCLE GUIDING MECHANISM WITH A DWELL

LW

D



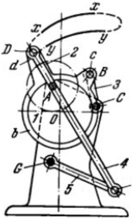
The lengths of the links comply with the conditions: $\overline{O_3B} = \overline{O_3D} = 1$, $\overline{O_1A} = 1.55$, $\overline{AB} = 0.418$, $\overline{O_1O_3} = 2.18$, $\overline{BM} = 0.983$, $\overline{AM} = 1.23$, $\overline{CM} = 2.46$, $\overline{O_2C} = 0.526$, $\overline{O_1O_2} = 0.608$, $\overline{O_3O_2} = 2.51$, $\overline{FD} = 1.51$, $\overline{O_4F} = 0.92$, $\overline{O_4O_3} = 1.795$, and $\overline{O_4O_1} = 3.82$. For the specified dimensions of the links, point M describes a path which closely approximates a circular arc over its full length. The radius of the arc equals link length $\overline{MC}$ and the centre is at point C. As a result, link O_2C is almost stationary during the whole period of motion of crank O_4F, i.e. it practically has a dwell during the whole period of motion of the mechanism.

761

ECCENTRIC-TYPE MULTIPLE-BAR TWO-DWELL MECHANISM

LW

D

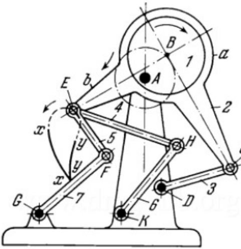


The lengths of the links comply with the conditions: $\overline{OB} = 2\overline{OA}$, $\overline{CB} = 1.25\overline{OA}$, $\overline{AC} = 2\overline{OA}$, $\overline{DE} = 6.5\overline{OA}$, $\overline{GE} = 2.8\overline{OA}$, $\overline{OD} = 2.62\overline{OA}$, $\overline{AG} = 3.15\overline{OA}$ and $\overline{BD} = 2.5\overline{OA}$. Eccentric *1*, with its centre at point *O*, turns about fixed axis *A*. Connecting rod *2* has collar *b* which encircles eccentric *1*. Collar *b* has two lugs *d* and *c* which are connected by turning pairs *D* and *B* to links *4* and *3*. Point *D* of connecting rod *2* describes a path of which portions *x-x* and *y-y*, shown by heavy continuous lines, approximate a circular arc of radius $\overline{ED}$ with the centre at point *E*. When point *D* is on these portions, link *5* has dwells.

762

ECCENTRIC-TYPE MULTIPLE-BAR TWO-DWELL MECHANISM

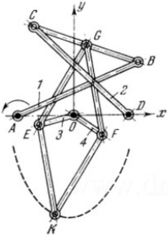
LW
D



The lengths of the links comply with the conditions: $\overline{BC} = 4\overline{AB}$, $\overline{DC} = 2.24\overline{AB}$, $\overline{AD} = 3.25\overline{AB}$, $\overline{BE} = 3.34\overline{AB}$, $\overline{EC} = 5.7\overline{AB}$, $\overline{EH} = 3.34\overline{AB}$, $\overline{EF} = 1.63\overline{AB}$, $\overline{GF} = \overline{KH} = 2.67\overline{AB}$, $\overline{AK} = 4.13\overline{AB}$, $\overline{AG} = 5\overline{AB}$, $\overline{GK} = 2.5\overline{AB}$ and $\overline{KD} = 1.44\overline{AB}$. Eccentric *1*, having its centre at point *B* turns about fixed axis *A*. Connecting rod *2* has collar *a* which encircles eccentric *1* and is connected by turning pair *C* to link *3* which turns about fixed axis *D*. Collar *a* has lug *b* which is connected by turning pairs *E* to links *4* and *5*. Point *E* of connecting rod *2* describes a path of which portions *x-x* and *y-y* approximate circular arcs of radii $\overline{HE}$ and $\overline{FE}$ and are shown by heavy continuous lines. When point *E* is on these portions, links *7* and *6* have dwells. The dwells of links *7* and *6* follow immediately one after the other.

10. MECHANISMS FOR GENERATING CURVES
(763 through 771)

763	KLEIBER MULTIPLE-BAR MECHANISM FOR DRAWING ELLIPSES	LW Ge



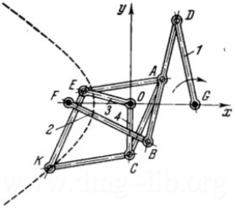
The lengths of the links comply with the conditions: $\overline{OE} = \overline{OF} = n$, $\overline{CG} = \overline{GB}$, $\overline{AB} = \overline{DC} = a$, $\overline{CB} = \overline{AD} = b$ and $\overline{EG} = \overline{GF} = \overline{FK} = \overline{KE} = m$. Figure *EGFK* is a rhombus linkage and figure *ABCD* is a crossed-crank linkage. Links *1* and *2* turn about fixed axes *A* and *D*. Links *3* and *4* turn about fixed axis *O*. If $a > b$ then, when link *1* turns about axis *A*, point *K* describes an ellipse with the equation

$$\frac{x^2}{\frac{m^2-n^2}{a^2}} + \frac{y^2}{\frac{m^2-n^2}{a^2-b^2}} = 1.$$

764

KLEIBER MULTIPLE-BAR MECHANISM FOR DRAWING HYPERBOLAS

LW
Ge



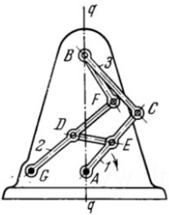
The lengths of the links comply with the conditions: $\overline{FB}=\overline{GD}=a$, $\overline{FG}=\overline{BD}=\sqrt{2}a=b$, $\overline{AC}=\overline{CK}=\overline{KE}=\overline{EA}=m$ and $\overline{OE}=\overline{OC}=n$. Figure $ACKE$ is a rhombus linkage and figure $FBDG$ is a crossed-crank linkage. Links 1 and 2 turn about fixed axes G and F. Links 3 and 4 turn about fixed axis O. When link 1 turns about axis G, point K describes a hyperbola with the equation

$$\frac{x^2}{\frac{m^2-n^2}{a^2}}-\frac{y^2}{\frac{m^2-n^2}{b^2-a^2}}=1.$$

765

HART MULTIPLE-BAR MECHANISM FOR DRAWING ELLIPSES

LW
Ge



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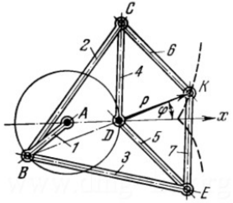
The lengths of the links comply with the conditions: $\overline{AC} = \overline{CB}$, $\overline{AG} = \overline{DG} = \overline{BF} = \frac{\overline{AC}}{\sqrt{2}}$, $\overline{GF} = \sqrt{2}\,\overline{AC}$ and $\overline{DE} = \overline{AE}$. Figure *GDEA* is a rhomboid linkage. When link *1* turns about fixed axis *A*, point *B* describes straight line *q*-*q*. Intermediate points of link *3* describe ellipses.

766

MULTIPLE-BAR MECHANISM FOR DRAWING CISSOIDS

LW

Ge



The lengths of the links comply with the conditions: $\overline{BC} = \overline{BE}$, $\overline{DC} = \overline{CK} = \overline{KE} = \overline{ED}$ and $\overline{AB} = \overline{AD}$. Thus links *2*, *3*, *4*, *5*, *6* and *7* constitute an inversor. When link *1* turns about fixed axis *A*, point *K* describes a cissoid with the polar equation

$$\rho = \frac{a + 2k \sin^2\varphi}{\cos\varphi}$$

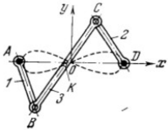
where a is the value of radius vector ρ when $\varphi = 0$, and φ is the angle of rotation of radius vector ρ.

767

FOUR-BAR CROSSED-CRANK LINKAGE FOR DRAWING LEMNISCATOIDS

LW

Ge



The lengths of the links comply with the conditions: $\overline{AD} = \overline{BC} = 2b$ and $\overline{AB} = \overline{DC} = a$. Figure $ABCD$ is a crossed-crank linkage. When crank *1* or *2* turns about fixed axis A or D, point K at the middle of connecting rod *3* describes a lemniscatoid with the equation

$$(x^2 + y^2)^2 = a^2 (x^2 - y^2) - 4b^2y^2$$

If the lengths of the links comply with the condition

$$a = \sqrt{2}b$$

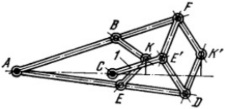
then point K describes a figure-of-eight curve, or Bernoulli lemniscate.

768

WILSON MULTIPLE-BAR MECHANISM FOR DRAWING ISOMETRIC REPRESENTATIONS

LW

Ge



The lengths of the links comply with the conditions: $\overline{AF} = \overline{AD}$, $\overline{BK} = \overline{KE}$ and $\overline{E'F} = \overline{FK'} = \overline{K'D} = \overline{DE'}$. When crank *1* turns about fixed axis *C*, point *K* provides for image distortion in the vertical direction with a distortion factor equal to

$$\alpha = \frac{\overline{AB}}{\overline{AF}} = \frac{\overline{AE}}{\overline{AD}} = \frac{\overline{BK}}{\overline{FK'}} = \frac{\overline{EK}}{\overline{DK'}}.$$

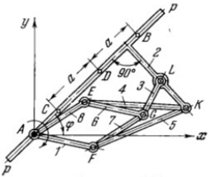
There is no distortion along axis *AC*. To reproduce an isometric representation, point *K'* is traced around the required contour. Then, shifting the drawing with the distorted contour to one side, the required supplementary details are added. If $\alpha = \frac{1}{\sqrt{3}}$ we obtain an isometric projection.

769

PEAUCELLIER MULTIPLE-BAR PROJECTOR MECHANISM

LW

Ge



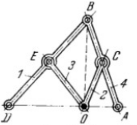
The lengths of the links comply with the conditions: $\overline{AE} = \overline{EG} = \overline{GF} = \overline{AF}$, $\overline{EK} = \overline{FK}$ and $\overline{GL} = \overline{LK}$. The mechanism is based on the Peaucellier inversor which consists of rhombus linkage *AEGF* and rhomboid linkage *AEKF*. Link *3* is connected by turning pair *L* to link *2* and by turning pair *G* to links *6* and *7*. Link *2* is connected by turning pair *K* to links *4* and *5*. Link *2* belongs to straight rule *p-p*. As a result of the specified relationships, line *p-p* always passes through fixed point *A*. If point *D* is traced along an arbitrary curve, points *C* and *B*, at equal distances *a* from point *D*, describe curves with the polar equation $\rho = \overline{AD} - a$. Vector $\boldsymbol{\rho}$ makes angle φ with axis *Ax*.

770

JOHNSON MULTIPLE-BAR EXTRACTOR MECHANISM

LW

Ge



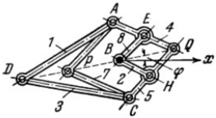
The lengths of the links comply with the conditions: $\overline{DE} = \overline{EB} = \overline{EO} = l/2$ and $\overline{AC} = \overline{OC} = \overline{CB} = m/2$. The mechanism is based on two lambda-shaped Chebyshev groups, consisting of links *1* and *3*, and *2* and *4*, connected by turning pairs *B* and *O*. If point *A* is traced along any curve having a polar equation of the form $\rho_A = \rho_A(\varphi)$, (where $\rho_A = \overline{OA}$ and φ is the polar angle made by line *DOA* and the polar axis, then point *D* describes a curve with an equation $\rho_D = \rho_D(\varphi)$. Quantities ρ_A and ρ_D are related by the condition $\rho_D^2 = \rho_A^2 \pm k^2$, where $k^2 = l^2 - m^2 = \text{const}$.

771

SYLVESTER MULTIPLE-BAR EXTRACTOR MECHANISM

LW

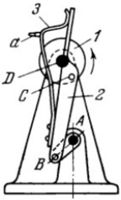
Ge



The lengths of the links comply with the conditions: $\overline{PA} = \overline{AQ} = \overline{QC} = \overline{CP} = b$, $\overline{EQ} = \overline{QH} = \overline{HB} = \overline{BE}$ and $\overline{DA} = \overline{DC} = a$. Figures *PAQC* and *EQHB* are rhombus linkages; figure *APCD* is a rhomboid linkage. If point *Q* traces along any curve $\rho_Q = \rho_Q(\varphi)$, where $\rho_Q = \overline{BQ}$ and φ is the polar angle made by line *DPBQ* and axis *Bx*, then point *D* describes a curve with the polar equation $\rho_D = \rho_D(\varphi)$. Quantities ρ_Q and ρ_D are related by the condition $\rho_D^2 = \rho_Q^2 \pm k^2$, where $k^2 = a^2 - b^2 = \text{const}$.

11. OPERATING CLAW MECHANISMS OF MOTION PICTURE CAMERAS (772 through 780)

772	FOUR-BAR MOTION PICTURE CAMERA OPERATING CLAW MECHANISM WITH A SPRING ON THE CONNECTING ROD	LW OC



When crank *1* rotates, the tip of claw *a*, mounted on flat spring *3* which is joined to connecting rod *2* of four-bar linkage *ABCD*, describes a connecting-rod curve. At one of the portions of this curve, claw *a* engages a perforation of the film which it moves. At another portion of the connecting-rod curve, claw *a* is withdrawn from the perforation.

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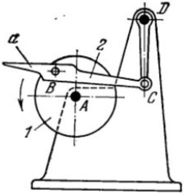
773	FOUR-BAR OPERATING CLAW MECHANISM OF A MOTION PICTURE CAMERA	LW OC



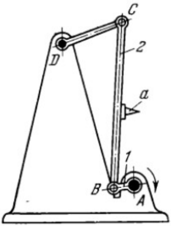
When crank *1* of four-bar linkage *ABCD* rotates about fixed axis *A*, the tip of claw *a* of connecting rod *2* describes a connecting-rod curve. At one of the portions of this curve, claw *a* engages a perforation of the film which it moves. At another portion of the connecting-rod curve, claw *a* is withdrawn from the perforation.

774

FOUR-BAR OPERATING CLAW MECHANISM OF A MOTION PICTURE CAMERA

LW

OC



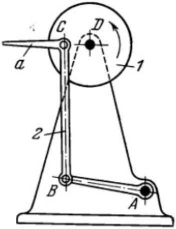
When crank *1* of four-bar linkage *ABCD* rotates about fixed axis *A*, the tip of claw *a*, mounted on connecting rod *2*, describes a connecting-rod curve. At one of the portions of this curve, claw *a* engages a perforation of the film which it moves. At another portion of the connecting-rod curve, claw *a* is withdrawn from the perforation.

775

FOUR-BAR OPERATING CLAW MECHANISM OF A MOTION PICTURE CAMERA

LW

OC

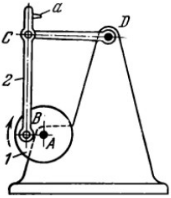


When crank *1* of four-bar linkage *ABCD* rotates about fixed axis *D*, the tip of claw *a*, mounted on connecting rod *2*, describes a connecting-rod curve. At one portion of this curve, claw *a* engages a perforation of the film which it moves. At another portion of the connecting-rod curve, claw *a* is withdrawn from the perforation.

776

FOUR-BAR OPERATING CLAW MECHANISM OF A MOTION PICTURE CAMERA

LW
OC



When crank *1* of four-bar linkage *ABCD* rotates about fixed axis *A*, the tip of claw *a*, mounted on connecting rod *2*, describes a connecting-rod curve. At one of the portions of this curve, claw *a* engages a perforation of the film which it moves. At another portion of the connecting-rod curve, claw *a* is withdrawn from the perforation.

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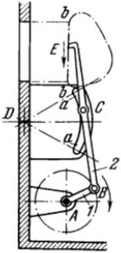
777

FOUR-BAR OPERATING CLAW MECHANISM OF A MOTION PICTURE CAMERA

LW
OC



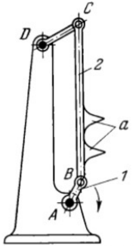
When crank *1* of four-bar linkage *ABCD* rotates about fixed axis *A*, the tip of claw, or hook, *E*, mounted on connecting rod *2*, describes a connecting-rod curve. At portion *b-b* of this curve, claw *E* engages a perforation of the film which it moves. At another portion of the connecting-rod curve, claw *E* is withdrawn from the perforation. Pin *C* of connecting rod *2* slides along arc-shaped guide *a-a* whose centre is at point *D*.

778

FOUR-BAR OPERATING CLAW MECHANISM OF A MOTION PICTURE CAMERA

LW

OC



When crank *1* of four-bar linkage *ABCD* rotates about fixed axis *A*, the tips of claws *a*, mounted on connecting rod *2*, describe a connecting-rod curve. At one of the portions of this curve, claws *a* engage perforations of the film which they move. At another portion of the connecting-rod curve, claws *a* are withdrawn from the perforations.

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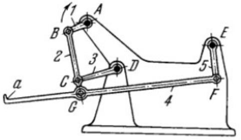
779

FOUR-BAR OPERATING CLAW MECHANISM OF A MOTION PICTURE CAMERA

LW

OC



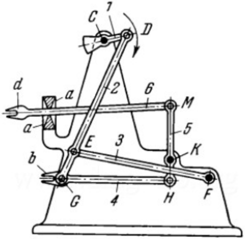
Link *4* is connected by turning pair *G* to connecting rod *2* of four-bar linkage *ABCD*, and by turning pair *F* to rocker arm *5*. When crank *1* rotates about fixed axis *A*, the tip of claw *a* describes a complex connecting-rod curve. At one of the portions of this curve, claw *a* engages a perforation of the film which it moves. At another portion of the connecting-rod curve, claw *a* is withdrawn from the perforation.

780

MULTIPLE-BAR OPERATING CLAW MECHANISM OF A MOTION PICTURE CAMERA

LW

OC

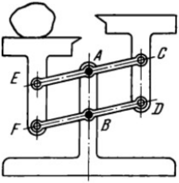


Connecting rod *2* of four-bar linkage *CDEF* is connected by turning pair *G* to link *4* which, in turn, is connected by turning pair *H* to link *5*. Link *5* turns about fixed axis *K* and is connected by turning pair *M* to link *6* which slides along rounded fixed guide *a*. When crank *1* rotates about fixed axis *C*, claws *b* describe a connecting-rod curve. At a portion of this curve, claws *b* engage perforations of the film, move the film and are withdrawn again. Claws *d* are inserted into perforations of the film to restrain it from movement at the moment that claws *b* are being withdrawn.

12. BALANCE MECHANISMS (781 through 795)

781 MULTIPLE-BAR PLATE BALANCE

LW
B



The lengths of the links comply with the conditions: $\overline{AB} = \overline{CD} = \overline{EF}$ and $\overline{AC} = \overline{BD} = \overline{EA} = \overline{BF}$. Thus the right- and left-hand parts of the mechanism are parallel-crank linkages.

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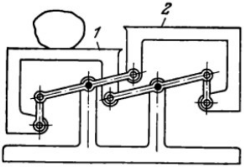
782 MULTIPLE-BAR PLATE BALANCE

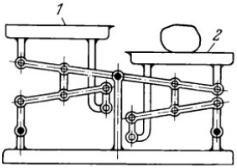
LW
B



The mechanism has two degrees of movement. Certainty of motion is provided for by the force loads from pans *1* and *2* and the loads being weighed. Equilibrium of the system is achieved by selecting the masses of the links. Owing to the equality of the link lengths at the right- and left-hand parts of the balance and their symmetrical arrangement, pans *1* and *2* have translational motion.

783 | **LW B**

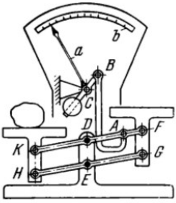
MULTIPLE-BAR PLATE BALANCE



The mechanism has three degrees of movement. Certainty of motion is provided for by the force loads from pans *1* and *2* and the loads being weighed. Equilibrium of the system is achieved by selecting the masses of the links. Owing to the equality of the link lengths in the right- and left-hand parts of the balance and their symmetrical arrangement, pans *1* and *2* have translational motion.

784 | **LW B**

MULTIPLE-BAR DIAL BALANCE

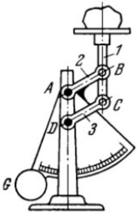


The lengths of the links comply with the conditions: $\overline{DE} = \overline{FG} = \overline{KH}$ and $\overline{DF} = \overline{EG} = \overline{EH} = \overline{DK}$. Thus, the right- and left-hand parts of the mechanism are parallel-crank linkages. Weighing can be done either directly on the pans or by means of supplementary indicating mechanism *ABC* having hand *a* and dial scale *b*.

785 MULTIPLE-BAR SINGLE-PAN BALANCE

LW

B



The lengths of the links comply with the conditions: $\overline{AB} = \overline{DC}$ and $\overline{AD} = \overline{BC}$. When a load is placed on the pan, link *1* has translational motion. Link *2* and the scale sector with weight *G*, both rigidly secured to link *2*, turn about fixed axis *A* until equilibrium is reached. The indicated weight depends upon the angle of rotation of the sector with weight *G*, and is read off the scale.

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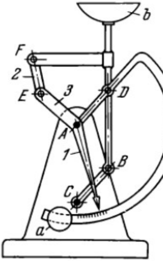
786 MULTIPLE-BAR SINGLE-PAN BALANCE

LW

B

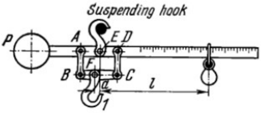


The lengths of the links comply with the conditions: $\overline{AD} = \overline{CB}$ and $\overline{AC} = \overline{DB}$. Thus the basic mechanism of the balance is parallel-crank linkage *ADBC*. The system of additional levers *2* and *3* deflect hand *1* through the corresponding angle. Weight *a* counterbalances the weight of pan *b* and of the links of the mechanism.

787

DIFFERENTIAL STEELYARD

LW
B

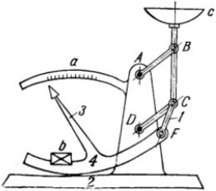


The lengths of the links comply with the conditions: $\overline{AB} = \overline{DC}$, $\overline{AD} = \overline{BC}$ and $\overline{AE} = \overline{ED}$. Hook *1* is connected by turning pair *F* to link *BC* of parallel-crank linkage *ABCD*. Point *F* of the hook suspension is displaced by the distance *a* from point *E*. Weight *Q* of the load being weighed equals $Q = G\frac{l}{a}$, where *G* is the sliding weight and *l* is the arm of the sliding weight with respect to point *E*. Arm *a* can be very small so that the length of the beam need be relatively short. Weight *P* counterbalances the dead weight of the beam.

788

MULTIPLE-BAR SINGLE-PAN BALANCE WITH A ROLLING LEVER

LW
B



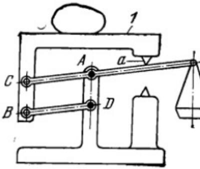
The lengths of the links comply with the conditions: $\overline{AB} = \overline{DC}$ and $\overline{AD} = \overline{BC}$. Thus the basic mechanism of the balance is a parallel-crank linkage *ABCD*. When pan *c* of the balance descends, link *1* actuates shaped lever *4* which rolls along flat surface *2* and carries hand *3*. Dial scale *a* requires special graduation. Weight *b* counterbalances the weights of the pan and the links of the mechanism.

789

MULTIPLE-BAR PLATFORM SCALES

LW

B



The lengths of the links comply with the conditions: $\overline{AC} = \overline{DB}$ and $\overline{AD} = \overline{CB}$. Thus the basic mechanism of the scales is parallel-crank linkage *ACBD*. Platform *1* has translational motion. Stop *a* constrains the mechanism when pan *2* is not loaded.

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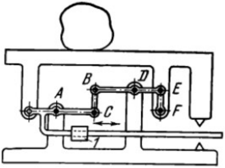
790

MULTIPLE-BAR PLATFORM SCALES

LW

B

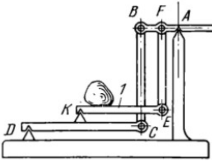


The lengths of the links comply with the conditions: $\overline{AC} = \overline{BD}$ and $\overline{BC} = \overline{EF}$. Thus the basic mechanism of the scales is four-bar linkage *ACBD*. The load being weighed is counterbalanced by abjusting rider *1* along its beam.

791

MULTIPLE-BAR PLATFORM SCALES

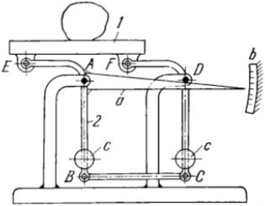
LW
B



The lengths of the links comply with the conditions: $\overline{KE} = \overline{EF}$ and $\overline{DK} : \overline{DC} = \overline{FA} : \overline{AB} = k$. If link *1* is the platform and it carries load Q being weighed, the weight of this load is $Q = G \frac{1}{k} \frac{\overline{AF}}{\overline{AB}}$, where G is the weight placed in pan *2*.

792 MULTIPLE-BAR PLATFORM SCALES

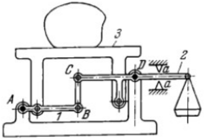
LW
B



The lengths of the links comply with the conditions: $\overline{AB} = \overline{DC}$, $\overline{AD} = \overline{BC} = \overline{EF}$, $\overline{AE} = \overline{DF}$ and $\overline{BE} = \overline{CF}$. Thus the basic mechanism of the scales is parallel-crank linkage *ABCD*. Platform *1* has translational motion. Rigidly secured to link *2* is hand *a* which indicates the weight being weighed on scale *b*. Weights *c* counterbalance the weight of platform *1* and the links of the mechanism.

793 MULTIPLE-BAR PLATFORM SCALES

LW
B

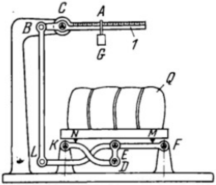


The basic mechanism of the scales is four-bar linkage *ABCD*, to whose links, *1* and *2*, platform *3* is connected by turning pairs. Link *2* turns through a small angle within the limits permitted by stops *a*. Since it is a kinematically rigid system, lever *2* can turn due to the small clearances in the hinge joints.

794

MULTIPLE-BAR PLATFORM SCALES

LW
B



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The lengths of the links comply with the condition: $\overline{KN} : \overline{EK} = \overline{MF} : \overline{FE}$. When the platform is loaded, beam *1* is deflected from the horizontal position. A state of equilibrium is achieved by moving weight G along beam *1*. Then weight G is related to the weight Q of the load being weighed by the equation

$$G = Q \frac{\overline{EF}}{\overline{LE}} \frac{\overline{BC}}{\overline{AC}}.$$

The lengths of the links are designed so that for the maximum arm length $\overline{AB}$, the product

$$\frac{\overline{EF}}{\overline{LE}} \times \frac{\overline{BC}}{\overline{AC}}$$

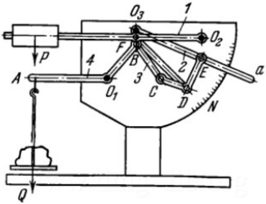
equals 10 or 100 (decimal or centesimal scales).

795

CHEBYSHEV MULTIPLE-BAR BALANCE

LW

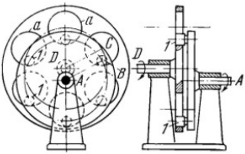
B



The lengths of the links comply with the conditions: $\overline{O_1A} = 1$, $\overline{O_1B} = 0.692$, $\overline{AB} = 1.5$, $\overline{BC} = 0.693$, $\overline{CE} = 0.626$, $\overline{CD} = 0.353$, $\overline{DE} = 0.442$, $\overline{O_3E} = 0.941$, $\overline{O_1O_3} = 0.692$, $\overline{DF} = 0.98$, $\overline{O_2F} = 0.892$, $\overline{O_2O_3} = 0.892$ and $\overline{O_1O_2} = 1.42$. For the specified dimensions, points O_3, F and B practically coincide (they are conditionally shown as not coinciding). Closed kinematic chain O_3EDFO_2 is a five-bar linkage having two degrees of movement. Weight P is mounted on the extension of link *1*. End *a* of link *2* serves as a hand travelling along scale N. Intermediate link *3* connects the basic mechanism to lever *4* at whose point A load Q is suspended. Weighing is performed by getting link O_2F into the horizontal position. Hand *a* indicates the weight Q of the load on scale N. Counterweight P is interchangeable. Each counterweight P is used with a correspondingly graduated scale. Scale N has approximately equal graduations.

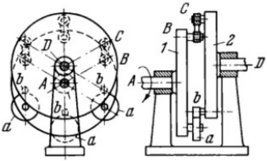
13. CLUTCH AND COUPLING MECHANISMS
(796 through 801)

796	**COUPLING MECHANISM WITH PARALLEL-CRANK LINKAGES**	LW C



The lengths of the links comply with the conditions: $\overline{AD} = \overline{BC}$ and $\overline{AB} = \overline{DC}$. Rotation is transmitted between two offset shafts A and D by a sixfold repeated parallel-crank linkage $ABCD$. The linkage has rollers 1 rolling around in circular holes a, of a radius equal to the distance between axes A and D plus the roller radius. Shafts A and D have equal angular velocity.

797	**COUPLING MECHANISM WITH PARALLEL-CRANK LINKAGES**	LW C

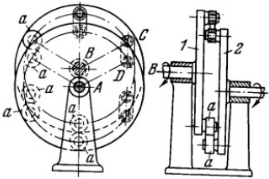


The lengths of the links comply with the conditions: $\overline{AD} = \overline{BC}$ and $\overline{AB} = \overline{DC}$. Rotation is transmitted between offset shafts A and D. Owing to the fact that there are three paired parallel-crank linkages, there is no uncertainty of motion at the extreme positions (dead points). Disks 1 and 2 have three pairs of freely rotating rollers a and b. The sum of the radii of the rollers equals $\overline{AD}$. Shafts A and D have equal angular velocity.

798

COUPLING MECHANISM WITH PARALLEL-CRANK LINKAGES

LW
C

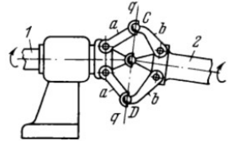


The lengths of the links comply with the conditions: $\overline{AB} = \overline{CD}$ and $\overline{BC} = \overline{AD}$. Rotation is transmitted between two offset shafts A and B by a threefold repeated parallel-crank linkage $ABCD$. Disks *1* and *2* have three pairs of freely rotating rollers a. The radius of the rollers equals $\overline{AB}/2$. Shafts A and B have equal angular velocity.

799

MULTIPLE-BAR SPATIAL COUPLING

LW
C

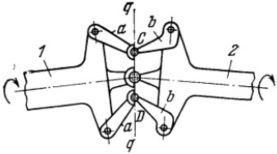


Link *1* is connected by a spherical pair to link *2*. Links *1* and *2* have levers a and b which are connected together by spherical pairs C and D. Owing to the symmetrical arrangement of levers a and b, links *1* and *2* may be angularly misaligned about axis q-q with respect to each other.

800

MULTIPLE-BAR SPATIAL COUPLING

LW
C

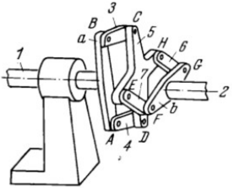


Link *1* is connected by a spherical pair to link *2*. Links *1* and *2* have levers *a* and *b* which are connected together by spherical pairs *C* and *D*. Owing to the symmetrical arrangement of levers *a* and *b*, links *1* and *2* may be angularly misaligned about axis *q*-*q* with respect to each other.

801

MULTIPLE-BAR COUPLING WITH TWO PARALLEL-CRANK LINKAGES

LW
C

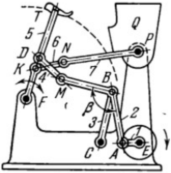


The lengths of the links comply with the conditions: $\overline{AB} = \overline{DC}$, $\overline{BC} = \overline{AD}$, $\overline{EH} = \overline{FG}$ and $\overline{EF} = \overline{HG}$. Cross-piece *a* is secured rigidly to shaft *1* and cross-piece *b* to shaft *2* whose axis does not coincide with, but is parallel to, the axis of shaft *1*. Cross-type connecting rod *5* is connected by turning pairs *C*, *D*, *H* and *E* to cranks *3*, *4*, *6* and *7*. Rotation is transmitted from shaft *1* to shaft *2* through two parallel-crank linkages *ABCD* and *EFGH* which have a common cross-type connecting rod *5*.

14. SORTING AND FEEDING MECHANISMS

(802 through 808)

802	**CHEBYSHEV MULTIPLE-BAR SORTING MECHANISM**	**LW** **SF**



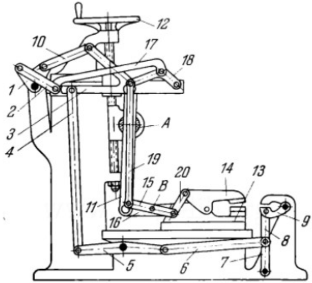
The lengths of the links comply with the conditions: $\overline{AB} = \overline{CB} = \overline{BM} = 1$, $\overline{EA} = 0.305$, $\overline{CE} = 0.76$, $MD = 0.66$, $\overline{FD} = 0.8$, $\overline{CF} = 1.66$, $\overline{EF} = 2.36$ and $\beta = 114°$. Point M of connecting rod *2* in four-bar linkage $EABC$ describes a connecting-rod curve of which a portion approximates a circular arc with its centre at point D (this arc is not shown) and of a radius equal to $\overline{DM}$ (link *4*). When point M is on this portion of its path, link *5* is almost stationary, i.e. it practically has a dwell at its extreme position. At the extreme right-hand position of link *5*, grain from hopper Q flows into trough T. Since the dwell of link *5* in this position corresponds to a half-revolution of crank *1*, the grain has the opportunity to fill trough T. In the next half-revolution of crank *1*, link *5* with trough T which is filled with grain makes one full oscillation. At this, the grain is scattered by the trough, the individual grains falling farther or nearer depending upon their size and mass. Link *7*, actuated by link *5* through intermediate link *6*, has a shutter which closes the output hole of hopper Q, opening it only during the dwell of link *5*.

803

ADJUSTABLE-STROKE MULTIPLE-BAR FEEDING MECHANISM

LW

SF

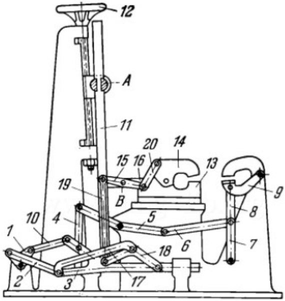


Upon rotation of two-arm crank *1*, motion is transmitted through links *10*, *2* and *3*, to lever *11*, pivotted at point *A*, and further through link *16* to sliding member *13* which reciprocates. Clamp *14* is opened and closed by means of links *2*, *17*, *18* and *19*, rocker arm *15* and link *20*. Clamp *9* is opened and closed by means of links *2*, *3* and *4*, rocker arm *5* and links *6*, *7* and *8*. The stroke of sliding member *13* is adjusted by turning handwheel *12*, thereby changing the position of pivot *A*. The angle of turn of clamp *14* depends upon the feed value because rocker arm *15* is connected to link *16* by pivot *B*.

804

ADJUSTABLE-STROKE MULTIPLE-BAR FEEDING MECHANISM

LW
SF



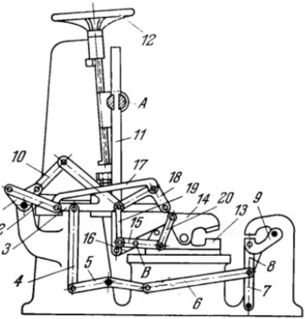
Upon rotation of two-arm crank *1*, motion is transmitted through links *10*, *2* and *3* to lever *11*, pivotted at point *A*, and further through link *16* to sliding member *13* which reciprocates. Clamp *14* is opened and closed by means of links *2*, *17*, *18* and *19*, rocker arm *15* and link *20*. Clamp *9* is opened and closed by means of links *2*, *3* and *4*, rocker arm *5* and links *6*, *7* and *8*. The stroke of sliding member *13* is adjusted by turning handwheel *12*, thereby changing the position of pivot *A*, the angle of turn of clamp *14* depends upon the feed value because rocker arm *15* is connected to link *16* by pivot *B*.

805

ADJUSTABLE-STROKE MULTIPLE-BAR FEEDING MECHANISM

LW

SF

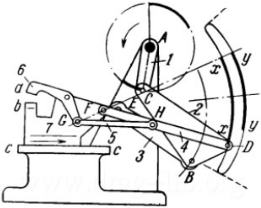


Upon rotation of two-arm crank *1*, motion is transmitted through links *10*, *2* and *3* to lever *11*, pivotted at point *A*, and further through link *16* to sliding member *13* which reciprocates. Clamp *14* is opened and closed by means of links *2*, *17*, *18* and *19*, rocker arm *15* and link *20*. Clamp *9* is opened and closed by means of links *2*, *3* and *4*, rocker arm *5* and links *6*, *7* and *8*. The stroke of sliding member *13* is adjusted by turning hand-wheel *12*, thereby changing the position of pivot *A*. The angle of turn of clamp *14* depends upon the feed value because rocker arm *15* is connected to link *16* by pivot *B*.

806

MULTIPLE-BAR FEEDING MECHANISM

LW
SF

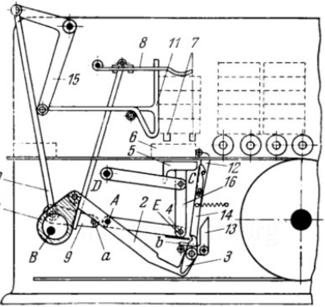


The lengths of the links comply with the conditions: $\overline{CB} = 2\overline{AC}$, $\overline{CD} = 2.4\overline{AC}$, $\overline{BD} = 0.9\overline{AC}$, $\overline{BE} = 2\overline{AC}$, $\overline{FD} = 3\overline{AC}$ and $\overline{AE} = 1.6\overline{AC}$. Sliding member *7* is reciprocated along guide *c-c* by link *4* which is connected by turning pair *D* to connecting rod *2*. Sliding member *7* has two dwells when point *D* is on portions *x-x* and *y-y* of its path, since these portions approximate circular arcs described from the corresponding positions of point *E*. Link *5* actuates link *6* for periodically clamping and unclamping the workpiece (or stock) between jaws *a* and *b*.

807

MULTIPLE-BAR FEEDING MECHANISM

LW
SF

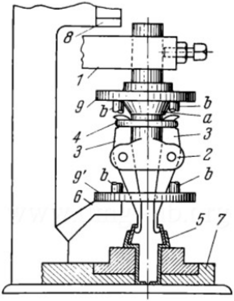


Upon rotation of eccentric *1* about fixed axis *B*, lever *2* oscillates about fixed axis *A*. At this, lever *3*, pivotted to lever *2*, engages pin *4* of link *16* in parallel-crank linkage *AECD*, and moves elevator *5* upwards, thereby lifting the next workpiece *6*, delivered by the conveyer, into a stack. The workpieces are held in the raised position by clips *7*. The stack of workpieces *6* reaches a definite preset height, after which lever *8* is deflected and pin *a* of lever *9* engages a clutch which is not shown. At this a special drive turns pivotted levers *10* and *15* so that pusher *11* shifts the finished stack onto the conveying device. After this, rotation of eccentric *1* is re-engaged. Workpiece *6* runs up against stop *12* which is in its extreme right-hand position when lever *2* turns downward. This is due to the fact that lug *b* of lever *3* turns angle lever *13* which, turning lever *14*, shifts stop-lever *12* to its extreme position. Thus, owing to the action of stop *12*, workpiece *6* is in a strictly definite position.

808

MULTIPLE-LINK EJECTOR MECHANISM

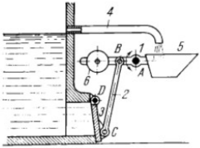
LW
SF



Upon a displacement of plate *1* downward cross-piece *2* begins to descend. At this, flange *9′*, joined by pins *b* to flange *9* which is mounted freely on cross-piece *2*, reaches stop *6* and clamps the ends of levers *3* by overcoming the resistance of spring *4*. The lower ends of levers *3* are brought together so that they enter and grip workpiece *5*. As plate *1* moves upward, cross-piece *2*, together with levers *3* and workpiece *5*, begins to rise, freeing feeding disk *7*. When flange *9* reaches upper stop *8*, flange *9* begins to descend with respect to cross-piece *2*, while plate *1* of the press continues to rise, completing its stroke. At this, cone *a* of the flange spreads the upper ends of levers *3*, thereby bringing their lower ends together to release the workpiece. Then plate *1* descends again with cross-piece *2*, levers *3* grip the next workpiece and the cycle is repeated.

809 FOUR-BAR SAFETY MECHANISM

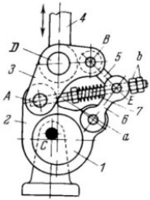
LW
S



The mechanism consists of four-bar linkage *ABCD*. When the level in the tank rises, liquid flows along pipe *4* into bucket *5*. Lever *1*, rigidly secured to the bucket, turns about fixed axis *A* and flap *3* is opened so that it rapidly lets out excess liquid from the tank. When bucket *5* empties, lever *1* is returned to its initial position by weight *6* which can be adjusted along the axis of lever *1* to regulate the device.

810 MULTIPLE-BAR OVERLOAD PROTECTION MECHANISM

LW
S

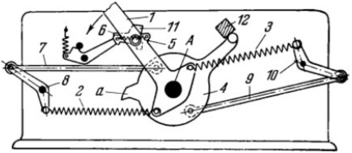


By means of connecting rod *2*, connected by turning pair *A* to angle lever *3*, motion is transmitted from eccentric *1*, rotating about fixed axis *C*, to reciprocating rod *4*. Lever *3* is connected by turning pair *D* to the rod and by turning pair *B* to lever *5* which, in turn, is connected by turning pair *E* to link *6*. Stem *a*, mounting spring *7*, is secured by one end in pivot *A* and the other end passes through a guide hole in pivot *E*. Preloading of the spring is regulated by nuts *b*. At a high load which stops the rod, the connecting rod is turned by eccentric *1* about point *B* so that levers *3* and *5* are turned and compress spring *7*.

811

MULTIPLE-BAR SAFETY MECHANISM

LW
S



When handle *1*, mounted freely on shaft *A*, is turned counterclockwise, springs *2* and *3* are stretched and actuate link *4* through links *7*, *8*, *9* and *10*. But link *4* cannot overtake handle *1* because its lug *a* engages pawl *11* which is pivotted on handle *1* and is actuated by spring *5*. When pawl *11* runs up against stop *6*, it overcomes the resistance of spring *5* and turns, releasing lug *a* of link *4*. Then link *4*, actuated by springs *2* and *3* through levers *7*, *8*, *9* and *10*, turns until its other lug reaches stop *12*. When handle *1* is turned further, springs *2* and *3* are stretched again. Pawl *11*, bearing against stop *6*, engages lug *a* of link *4*. When the lever is released, the stretched springs return the mechanism to its initial position. Thus, the torque on shaft *A*, transmitted from handle *1* to link *4*, is determined by the rigidity of springs *2* and *3* and the arrangement of levers *7*, *8*, *9* and *10*.

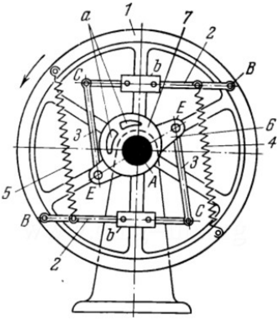
16. GOVERNOR MECHANISMS (812 through 815)

812

MULTIPLE-BAR CENTRIFUGAL GOVERNOR

LW

G



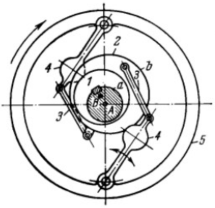
Disk *1* rotates about fixed axis *A*. Weights *b* are rigidly secured to links *2* which are connected by turning pairs *B* and *C* to disk *1* and links *3*. Lever *6*, rotating about axis *A*, is connected by turning pairs *E* to links *3*. Springs *4* and *5* pull links *2* toward the hub of disk *1*. When disk *1* rotates, weights *b* move outward by overcoming the resistance of springs *4* and *5*. This turns lever *6* to close ports *a* of eccentric *7*. The amount by which ports *a* are closed depends upon the speed of rotation of disk *1*. This regulates the admission of steam.

813

LEVER-ECCENTRIC MECHANISM OF A FLAT GOVERNOR

LW

G



Eccentric *1*, with its geometric centre at point *B*, is rigidly secured to fixed shaft *a*. Crank *2* is designed as a collar encircling eccentric *1*. When link *5* rotates, links *4* are turned outward by the action of the weights mounted on them. The angle through which links *4* turn depends upon the angular velocity of link *5*. The angle of swing of links *4* can be varied by clamping eccentric *1* in various positions on shaft *a*.

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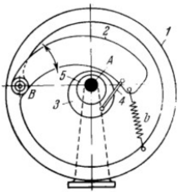
814

LEVER-ECCENTRIC MECHANISM OF A FLAT GOVERNOR

LW

G



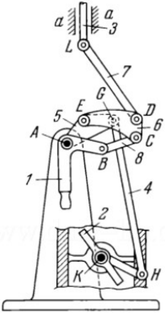
Eccentric *5* is rigidly secured to fixed shaft *A*. Crank *3* is designed as a collar encircling eccentric *5*. When link *1* rotates, link *2* is turned outward by mass forces with respect to axis *B* through various angles overcoming the resistance of spring *b*, depending upon the angular velocity of link *1*.

815

MULTIPLE-BAR AUTOMATIC PRESSURE REGULATOR

LW

G



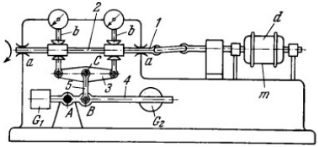
Handle *1* turns about fixed axis *A*. Piston rod *3* reciprocates in fixed guide *a-a*. Throttle valve *2* turns about fixed axis *K*. Link *4* is connected by turning pairs *H* and *G* to links *2* and *5* which turn about fixed axes *K* and *A*. Link *6* is connected by turning pairs *E*, *D* and *C* to links *5*, *7* and *8*. Link *8* is connected by turning pair *B* to handle *1*. When handle *1* is turned with piston rod *3* stationary, throttle valve *2* is set in a definite position providing for normal pressure. If the pressure increases, piston rod *3* descends, turning valve *2* without moving handle *1*. Handle *1* can be locked in a definite position by a device which is not shown.

17. MECHANISMS OF MEASURING AND TESTING DEVICES (816 through 824)

816

MULTIPLE-BAR MECHANISM FOR BENDING AND TORSION TESTS

LW
M

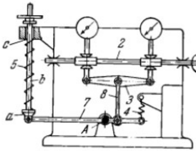


Shaft *1* with test-piece *2* rotates in bearings *a*. Lever *4* turns about fixed axis *A* and carries weights G_1 and G_2. Link *5* is connected by turning pairs *B* and *C* to links *4* and *3*. Two-armed lever *3* is hinged to loading devices *b*. Acting on loading devices *b*, weights G_1 and G_2 produce a bending moment. Upon rotation of shaft *1*, test-piece *2* is subjected to the simultaneous action of bending and torsion. Generator *d* of mass *m* serves to measure the magnitude of the transmitted torque.

817

MULTIPLE-BAR MECHANISM WITH ELASTIC LINKS FOR BENDING AND TORSION TESTS

LW
M



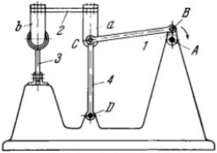
Springs *4* and *5*, acting through intermediate link *8* on two-arm lever *3*, develop a bending moment on the portion of test-piece *2*. Upon rotation of shaft *1*, test-piece *2* is subjected to the simultaneous action of bending and torsion. Spring *5* is precompressed and adjusted to exert a definite force. It is secured at one end to a fixed base and at the other to component *a* which belongs to rod *b* that slides in hole *c* of the base. Spring *4* is secured at one end to the fixed base and at the other to two-arm lever *7* which turns about fixed axis *A*.

818

MULTIPLE-BAR MECHANISM WITH AN ELASTIC LINK FOR TENSILE AND COMPRESSION TESTS ON FLAT TEST-PIECES

LW

M



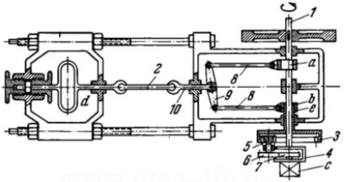
Link *3* is a flat calibrated spring. Flat test-piece *2* is clamped in components *a* and *b*. Component *b* belongs to link *3*. Component *a* is connected by turning pair *C* to rocker arm *4* of four-bar linkage *ABCD*. Upon rotation of crank *1*, test-piece *2* is subjected to an alternating (compression and tensile) load.

819

MULTIPLE-BAR MECHANISM FOR TENSILE TESTS

LW

M



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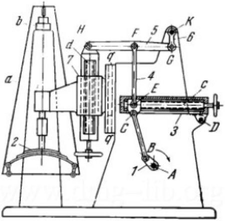
Shaft *1* with eccentric *a* is driven by an electric motor. Eccentric *b* is mounted on the hub of internal gear *3*. Secured on shaft *1* is carrier *4* which mounts gears *5*, *6* and *7*, and auxiliary electric motor *c*. Levers *8* are hinged to lever *9*. Upon rotation of shaft *1*, test-piece *2* is subjected to a variable tensile load by means of levers *8*, *9* and *10*. The amount of displacement of the head of the test-piece and, consequently, the magnitude of the applied load, can be varied during operation by turning eccentric *b* by means of electric motor *c*. The amount of strain is measured by pickup *d*.

820

MULTIPLE-BAR MECHANISM WITH ADJUSTING DEVICES FOR DYNAMIC LEAF SPRING TESTS

LW

M

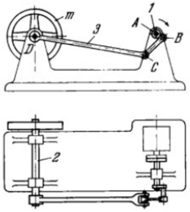


Rocker arm *3* of four-bar linkage *ABCD* oscillates about fixed axis *D*. Link *4* is connected by turning pairs *E* and *F* to rocker arm *3* and link *5*. Link *5* is connected by turning pairs *G* and *H* to link *6* and sliding member *7*. Link *6* turns about fixed axis *K*. Sliding member *7* slides in fixed guide *q-q*. Tested leaf spring *2* rests on frame *a* which, in turn, rests on load cell *b*. The amplitude of oscillation of leaf spring *2* is varied by screw *c*, and the initial load by screw *d*. When crank *1* rotates, leaf spring *2* being tested is subjected to a dynamic load.

821

MULTIPLE-BAR MECHANISM FOR TORSION TESTS

LW
M



Rocker arm *3* of four-bar linkage *ABCD* oscillates about fixed axis *D*. Test-piece *2* is connected to fly-wheel *m* which has a large moment of inertia. Upon the rotation of crank *1*, elastic vibrations are set up by rocker arm *3* in the elastic system consisting of test-piece *2* and mass *m*. The test-piece is subjected to the action of an alternating inertia torque.

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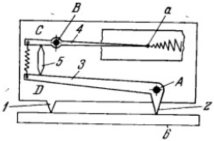
822

MULTIPLE-BAR RECORDING STRAIN GAUGE

LW
M

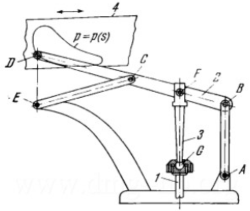


Lever *3* turns about fixed axis *A*. Lever *4* turns about fixed axis *B*. Knife-edges *C* and *D* of link *5* enter corresponding notches in levers *4* and *3*. Any changes in the distance between points *1* and *2* upon strain of test-piece *6* turns lever *3* and lever *4* with stylus *a*.

823

MULTIPLE-BAR APPROXIMATE STRAIGHT-LINE MECHANISM OF AN ENGINE INDICATOR

LW
M

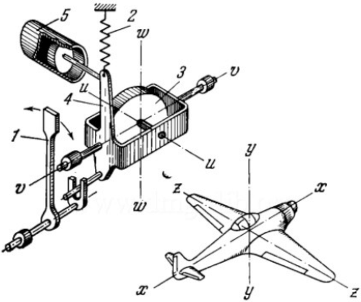


The lengths of the links comply with the conditions: $\overline{AB} = 1$, $\overline{BC} = \overline{CE} = \overline{CD} = 1.4$ and $\overline{AE} = 2.58$. Point D of the Chebyshev-type four-bar linkage $ABCD$ has approximate straight-line motion. The mechanism is driven by link *3* which is connected by turning pair F to link *2* and by spherical pair G to link *1*. Link *1* is connected by a system of links, not shown in the drawing, to the indicator which measures the pressure in the engine cylinder. The motion of link *1* is transformed into approximately rectilinear motion of the tracer, or pencil, which is at point D of link *2*. Paper strip *4* is moved a distance proportional to travel s of the piston in the engine cylinder. At this, the pencil traces the curve $p = p\ (s)$, where p is a quantity proportional to the steam or gas pressure in the cylinder.

824

MULTIPLE-BAR AIRCRAFT TURN INDICATOR

LW
M

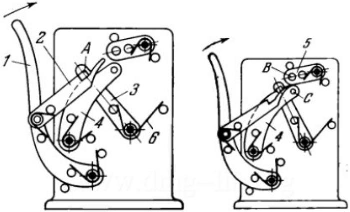


The instrument is set so that the gyroscope axes *u-u* and *v-v* coincide with axes *z-z* and *x-x* of the airplane. When the airplane turns about axis *x-x* or *z-z*, hand *1* remains stationary because spring *2*, secured to the frame of the instrument, sets axis *u-u* of gyroscope rotor *3* parallel to axis *z-z*. Spring *2* develops a counterbalancing moment, directed oppositely, with respect to axis *v-v*. The turn indicator shows right or left turns of the airplane. Damper *5* serves to damp the oscillations of hand *1*.

825

MULTIPLE-BAR INDEXING LEVER

LW
I

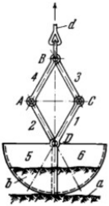


In the first clockwise swing of lever *1*, connecting rod *2* shifts indexing lever *3* clockwise until lug *A* of this lever drops into the slot of link *4*. Lever *3* is indexed in this position, shown in the right-hand drawing, when lever *1* is returned to its initial position. In the second clockwise swing of lever *1*, connecting rod *2*, sliding with its curvilinear surface between projections *B* and *C* of links *5* and *4*, disengages link *4* from lever *3* which is returned by the spring to its initial position shown in the left-hand drawing.

19. MECHANISMS OF MATERIALS HANDLING EQUIPMENT (826 through 830)

826 FOUR-BAR CLAMSHELL BUCKET MECHANISM

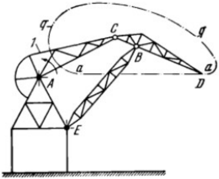
LW
MH



The lengths of the links comply with the conditions: $\overline{AB} = \overline{BC}$ and $\overline{AD} = \overline{CD}$. When suspension *d* is pulled upward, scoops *5* and *6* close over loose material *b* and load *b* is carried to the required location. To dump the bucket it is set down on the stationary material *a*. Scoops *5* and *6* rest on material *a* and point *B* descends so that the configuration of rhomboid linkage *ABCD* is changed, scoops *5* and *6* are opened releasing load *b*.

827 FOUR-BAR CRANE MECHANISM

LW
MH



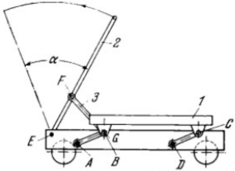
The lengths of the links of four-bar linkage *ACBE* comply with the conditions: $\overline{CB} = 0.27\overline{AC}$, $\overline{BD} = 0.83\overline{AC}$, $\overline{EB} = 1.18\overline{AC}$ and $\overline{AE} = 0.64\overline{AC}$. When link *1* is turned about fixed axis *A*, point *D* describes path *q-q* of which portion *a-a* approximates a straight line. The approximately rectilinear horizontal portion *a-a* of connecting-rod curve *q-q* is used to carry loads horizontally.

828

MULTIPLE-BAR HAND LIFT TRUCK MECHANISM

LW

MH

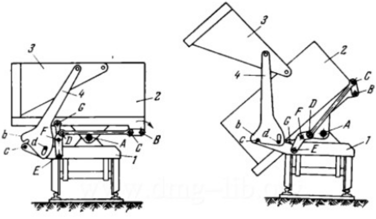


The lengths of the links comply with the conditions: $\overline{AB} = \overline{DC}$ and $\overline{BC} = \overline{AD}$. For the specified dimensions, platform *1* has translational motion when it is lifted. Lever *2* turns about fixed axis E and is connected by intermediate link *3* to platform *1*. Platform *1* is lifted to its full height by turning lever *2* through angle α.

829

MULTIPLE-BAR MECHANISM OF A DUMP CAR

LW
MH



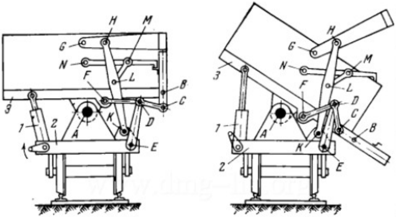
The mechanism of this side-dumping car consists of truck *1* and body *2* connected together by six-bar linkage *ABCDEFG* (see left-hand drawing). When link *BC* is turned clockwise, body *2* begins to overturn. At this, link *3* first moves slowly since link *4* bears on pin *d*. As soon as lug *b* engages pin *c*, link *3* is raised. Then the body is dumped and takes the position shown in the right-hand drawing.

830

MULTIPLE-BAR MECHANISM OF A DUMP CAR

LW

MH

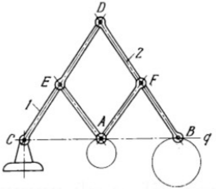


www.dmg-lib.org

The mechanism of this side-dumping car consists of body *2* and truck *3* connected together by two six-bar linkages, *ABCDEF* and *AGHKLMN*. Link *NM* is designed as a latch on its free end (see left-hand drawing). When jack *1* is operated, body *3* is lifted to the dumping position shown in the right-hand drawing. At this, six-bar linkage *AGHKLMN* opens the latch on link *NM* and raises link *GH*. Linkage *ABCDEF* swings open side *BC* and the load can be dumped at some distance from the car (see right-hand drawing).

20. PANTOGRAPH MECHANISMS (831 through 857)

831	MULTIPLE-BAR PANTOGRAPH MECHANISM	LW P

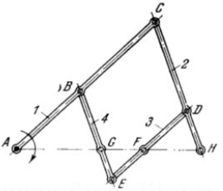


The lengths of the links comply with the conditions: $\overline{CD} = \overline{DB}$ and $\overline{ED} = \overline{FB} = \overline{DF} = \overline{FA} = \overline{AE} = \overline{CE}$. When point A traces around any outline lying in the plane of the drawing, point B of link 2, lying on straight line CAq describes a similar outline with a similarity factor k equal to

$$\frac{\overline{CD}}{\overline{CE}} = 2.$$

832 MULTIPLE-BAR PANTOGRAPH MECHANISM

LW
P



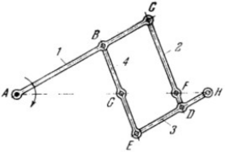
The lengths of the links comply with the conditions: $\overline{BC} = \overline{ED}$ and $\overline{EB} = \overline{DC}$, i.e. figure *EBCD* is a parallelogram linkage. An additional condition is that $\overline{AC} : \overline{CH} = \overline{FD} : \overline{DH} = \overline{AB} : \overline{BG}$. For any configuration of parallelogram linkage *EBCD*, points *A*, *G*, *F* and *H* lie on a single straight line. When link *1* turns about fixed axis *A*, selected as the centre of similarity, and one of the points, *G*, *F* or *H*, is traced along any arbitrary path, the other two points describe similar paths. The mechanism has reversibility since any point, *A*, *G*, *F* or *H*, can be selected as the centre of similarity.

833

MULTIPLE-BAR PANTOGRAPH MECHANISM

LW

P

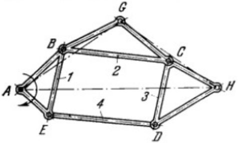


The lengths of the links comply with the conditions: $\overline{BC} = \overline{ED}$ and $\overline{EB} = \overline{DC}$, i.e. figure *EBCD* is a parallelogram linkage. An additional condition is that $\overline{AC} : \overline{CF} = \overline{HE} : \overline{EG} = \overline{AB} : \overline{BG} = \overline{HD} : \overline{DF}$. For any configuration of parallelogram linkage *EBCD*, points *A*, *G*, *F* and *H* lie on a single straight line. When link *1* turns about fixed axis *A*, selected as the centre of similarity, and one of the points, *G*, *F* or *H*, is traced along any arbitrary path, the other two points describe similar paths. The mechanism has reversibility since any point, *A*, *G*, *F* or *H*, can be selected as the centre of similarity.

834 MULTIPLE-BAR PANTOGRAPH MECHANISM

LW

P

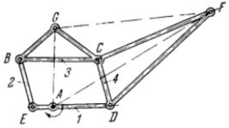


The lengths of the links comply with the conditions: $\overline{BC} = \overline{ED}$ and $\overline{EB} = \overline{DC}$, i.e. figure *EBCD* is a parallelogram linkage. Rigid triangle *GCB* is similar to triangle *GHA*. For any configuration of parallelogram linkage *EBCD*, triangle *GHA* retains constant angles at its vertices. When link *1* turns about fixed axis *A*, selected as the centre of similarity, and one of the points, *G* or *H*, is traced along any arbitrary path, the other point describes a similar path turned through a constant angle. The mechanism has reversibility since any point, *A*, *G* or *H*, can be selected as the centre of similarity.

835 MULTIPLE-BAR PANTOGRAPH MECHANISM

LW

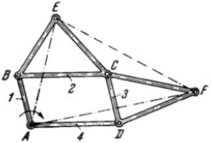
P



The lengths of the links comply with the conditions: $\overline{BC} = \overline{ED}$ and $\overline{EB} = \overline{DC}$, i.e. figure *EBCD* is a parallelogram linkage. Rigid triangle *FDC* is similar to triangle *FGA*. For any configuration of parallelogram linkage *EBCD*, triangle *FGA* retains constant angles at its vertices. When link *1* turns about fixed axis *A*, selected as the centre of similarity, and one of the points, *G* or *F*, is traced along any arbitrary path, the other point describes a similar path turned through a constant angle. The mechanism has reversibility since any point, *A*, *G* or *F*, can be selected as the centre of similarity.

836 MULTIPLE-BAR PANTOGRAPH MECHANISM

LW
P



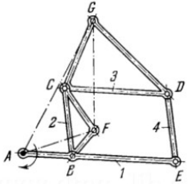
The lengths of the links comply with the conditions: $\overline{BC} = \overline{AD}$ and $\overline{AB} = \overline{DC}$, i.e. figure *ABCD* is a parallelogram linkage. Rigid triangle *ECB* is similar to triangle *EFA*. For any configuration of parallelogram linkage *ABCD*, triangle *EFA* retains constant angles at the vertices. When link *1* turns about fixed axis *A*, selected as the centre of similarity, and one of the points, *E* or *F*, is traced along any arbitrary path, the other point describes a similar path turned through a constant angle. The mechanism has reversibility since any point, *A*, *E* or *F*, can be selected as the centre of similarity.

837

MULTIPLE-BAR PANTOGRAPH MECHANISM

LW

P



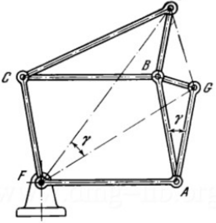
The lengths of the links comply with the conditions: $\overline{BC} = \overline{DE}$ and $\overline{CD} = \overline{BE}$, i.e. figure *BCDE* is a parallelogram linkage. Rigid triangle *FBC* is similar to triangle *FGA*. For any configuration of parallelogram linkage *BCDE*, triangle *FGA* retains constant angles at its vertices. When link *1* turns about fixed axis *A*, selected as the centre of similarity, and one of the points, *F* or *G*, is traced along any arbitrary path, the other point describes a similar path turned through a constant angle. The mechanism has reversibility since any point, *A*, *G* or *F*, can be selected as the centre of similarity.

838

SYLVESTER MULTIPLE-BAR PANTOGRAPH MECHANISM

LW

P



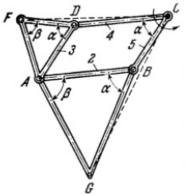
The mechanism is based on parallelogram linkage *ABCF* on whose sides *AB* and *BC*, two similar triangles, *ABG* and *BCE* have been constructed so that angle $\angle BAG = \angle ECB =$ $= \angle EFG = \gamma$. If point *G* is traced along any curve, then point *E* describes a similar curve, turned through angle γ with respect to the first curve.

839

SCHEINER MULTIPLE-BAR PANTOGRAPH MECHANISM

LW

P



The lengths of the links comply with the conditions: $\overline{AD} = \overline{BC}$ and $\overline{AB} = \overline{DC}$, i.e. figure $ADCB$ is a parallelogram linkage. Rigid triangles FDA and ABG are similar. Links 4 and 5 turn about fixed axis C which is the centre of similarity. When point F is traced along any arbitrary path, point G describes a similar path, turned through constant angle $\angle FCG = \alpha$. The similarity factor k of the pantograph equals

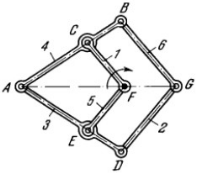
$$k = \frac{\overline{CF}}{\overline{CG}}.$$

840

MULTIPLE-BAR RHOMBOID PANTOGRAPH MECHANISM

LW

P

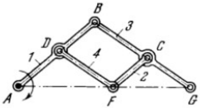


The lengths of the links comply with the conditions: $\overline{AB} = \overline{AD}$, $\overline{GB} = \overline{GD}$, $\overline{AC} = \overline{AE}$ and $\overline{FC} = \overline{FE}$. Figures $ACFE$ and $ABGD$ are rhomboid linkages. For any configuration of the mechanism, points A, F and G lie on a single straight line. When link 1 turns about fixed axis F, selected as the centre of similarity, and one of the points, A or G, is traced along any arbitrary path, the other point describes a similar path. The mechanism has reversibility since any point, A, G or F, can be selected as the centre of similarity.

841

MULTIPLE-BAR PANTOGRAPH MECHANISM

LW
P

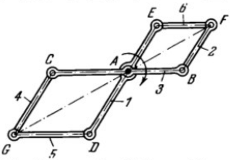


The lengths of the links comply with the conditions: $\overline{DB} = \overline{FC}$ and $\overline{BC} = \overline{DF}$, i.e. figure *DBCF* is a parallelogram linkage. Point *F* lies on the straight line through points *A* and *G* of links *1* and *3*. For any configuration of parallelogram linkage *DBCF*, points *A*, *F* and *G* lie on a single straight line. When link *1* turns about fixed axis *A*, selected as the centre of similarity, and one of the points, *F* or *G*, is traced along any arbitrary path, the other point describes a similar path. The mechanism has reversibility since any point, *A*, *F* or *G*, can be selected as the centre of similarity.

842

MULTIPLE-BAR PANTOGRAPH MECHANISM

LW
P



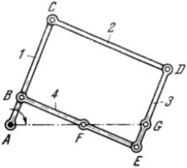
The lengths of the links comply with the conditions: $\overline{AD} = \overline{CG}$, $\overline{AC} = \overline{DG}$, $\overline{AE} = \overline{BF}$ and $\overline{EF} = \overline{AB}$, i.e. figures *ADGC* and *AEFB* are parallelogram linkages. For any configuration of the mechanism, points *G*, *A* and *F* lie on a single straight line. When link *1* turns about fixed axis *A*, selected as the centre of similarity, and one of the points, *F* or *G*, is traced along any arbitrary path, the other point describes a similar path. The mechanism has reversibility since any point, *A*, *F* or *G*, can be selected as the centre of similarity.

843

MULTIPLE-BAR PANTOGRAPH MECHANISM

LW

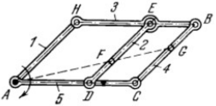
P



The lengths of the links comply with the conditions: $\overline{BC} = \overline{ED}$ and $\overline{CD} = \overline{BE}$, i.e. figure *BCDE* is a parallelogram linkage. Point *F* belongs to link *4* and lies on a straight line passing through points *A* and *G* of links *1* and *3*. For any configuration of parallelogram linkage *BCDE*, points *A*, *F* and *G* lie on a single straight line. When link *1* turns about fixed axis *A*, selected as the centre of similarity, and one of the points, *G* or *F*, is traced along any arbitrary path, the other point describes a similar path. The mechanism has reversibility since any point, *A*, *F* or *G*, can be selected as the centre of similarity.

844 MULTIPLE-BAR PANTOGRAPH MECHANISM

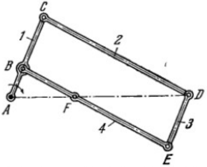
LW
P



The lengths of the links comply with the conditions: $\overline{AH} = \overline{DE} = \overline{CB}$, $\overline{HE} = \overline{AD}$ and $\overline{HB} = \overline{AC}$. Figures *AHBC* and *AHED* are parallelogram linkages. Points *F* and *G* of links *2* and *4* lie on an arbitrarily drawn straight line through point *A*. For any configuration of parallelogram *AHBC*, points *A*, *F* and *G* lie on a single straight line. When link *1* turns about fixed axis *A*, selected as the centre of similarity, and one of the points, *F* or *G*, is traced along any arbitrary path, the other point describes a similar path. The mechanism has reversibility since any point, *A*, *F* or *G*, can be selected as the centre of similarity.

845 MULTIPLE-BAR PANTOGRAPH MECHANISM

LW
P



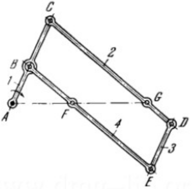
The lengths of the links comply with the conditions: $\overline{BC} = \overline{ED}$ and $\overline{CD} = \overline{BE}$, i.e. figure *BCDE* is a parallelogram linkage. Point *F* of link *4* lies on a straight line passing through points *A* and *D*. For any configuration of parallelogram linkage *BCDE*, points *A*, *F* and *D* lie on a single straight line. When link *1* turns about fixed axis *A*, selected as the centre of similarity, and one of the points, *F* or *D*, is traced along any arbitrary path, the other point describes a similar path. The mechanism has reversibility since any point, *A*, *F* or *D*, can be selected as the centre of similarity.

846

MULTIPLE-BAR PANTOGRAPH MECHANISM

LW

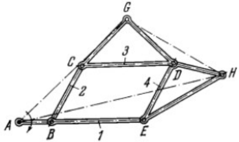
P



The lengths of the links comply with the conditions: $\overline{BC} = \overline{ED}$ and $\overline{CD} = \overline{BE}$, i.e. figure *BCDE* is a parallelogram linkage. Point *F* of link *4* lies on a straight line passing through points *A* and *G* of links *1* and *2*. For any configuration of parallelogram linkage *BCDE*, points *A*, *F* and *G* lie on a single straight line. When link *1* turns about fixed axis *A*, selected as the centre of similarity, and one of the points, *F* or *G*, is traced along any arbitrary path, the other point describes a similar path. The mechanism has reversibility since any point, *A*, *F* or *G*, can be selected as the centre of similarity.

847 MULTIPLE-BAR PANTOGRAPH MECHANISM

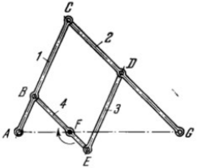
LW
P



The lengths of the links comply with the conditions: $\overline{BC} = \overline{ED}$ and $\overline{CD} = \overline{BE}$, i.e. figure *BCDE* is a parallelogram linkage. Rigid triangle *HED* is similar to triangle *GHA*. For any configuration of parallelogram linkage *BCDE*, triangle *GHA* retains constant angles at its vertices. When link *1* turns about fixed axis *A*, selected as the centre of similarity, and one of the points, *G* or *H*, is traced along any arbitrary path, the other point describes a similar path turned through a constant angle. The mechanism has reversibility since any point, *A*, *G* or *H*, can be selected as the centre of similarity.

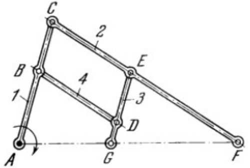
848 MULTIPLE-BAR PANTOGRAPH MECHANISM

LW
P



The lengths of the links comply with the conditions: $\overline{BC} = \overline{ED}$ and $\overline{CD} = \overline{BE}$, i.e. figure *BCDE* is a parallelogram linkage. Point *A* of link *1* lies on a straight line passing through points *F* and *G* of links **4** and *2*. For any configuration of parallelogram linkage *BCDE*, points *A*, *G* and *F* lie on a single straight line. When link **4** turns about fixed axis *F*, selected as the centre of similarity, and one of the points, *G* or *A*, is traced along any arbitrary path, the other point describes a similar path.

MULTIPLE-BAR PANTOGRAPH MECHANISM

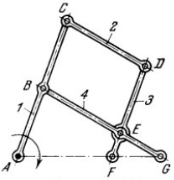


The lengths of the links comply with the conditions: $\overline{BC} = \overline{DE}$ and $\overline{BD} = \overline{CE}$, i.e. figure *BCED* is a parallelogram linkage. Point *G* of link *3* lies on a straight line passing through points *A* and *F* of links *1* and *2*. For any configuration of parallelogram linkage *BCED*, points *A*, *G* and *F* lie on a single straight line. When link *1* turns about fixed axis *A*, selected as the centre of similarity, and one of the points, *G* or *F*, is traced along any arbitrary path, the other point describes a similar path. The mechanism has reversibility since any point, *A*, *F* or *G*, can be selected as the centre of similarity.

850

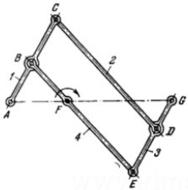
MULTIPLE-BAR PANTOGRAPH MECHANISM

LW
P



The lengths of the links comply with the conditions: $\overline{BC} = \overline{ED}$ and $\overline{CD} = \overline{BE}$, i.e. figure *BCDE* is a parallelogram linkage. Point *F* of link *3* lies on a straight line passing through points *A* and *G* of links *1* and *4*. For any configuration of parallelogram linkage *BCDE*, points *A*, *F* and *G* lie on a single straight line. When link *1* turns about fixed axis *A*, selected as the centre of similarity, and one of the points, *G* or *F*, is traced along any arbitrary path, the other point describes a similar path. The mechanism has reversibility since any point, *A*, *F* or *G*, can be selected as the centre of similarity.

851 MULTIPLE-BAR PANTOGRAPH MECHANISM LW P

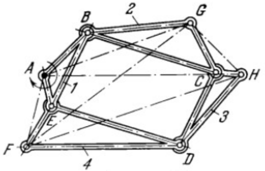


The lengths of the links comply with the conditions: $\overline{BC} = \overline{ED}$ and $\overline{CD} = \overline{BE}$, i.e. figure *BCDE* is a parallelogram linkage. Point *F* of link *4* lies on a straight line passing through points *A* and *G* of links *1* and *3*. For any configuration of parallelogram linkage *BCDE*, points *A*, *F* and *G* lie on a single straight line. When link *4* turns about fixed axis *F*, selected as the centre of similarity, and one of the points, *G* or *A*, is traced along any arbitrary path, the other point describes a similar path.

852 MULTIPLE-BAR PANTOGRAPH MECHANISM

LW

P

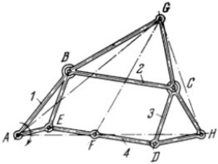


The lengths of the links comply with the conditions: $\overline{EB} = \overline{DC}$ and $\overline{BC} = \overline{ED}$, i.e. figure *EBCD* is a parallelogram linkage. Rigid triangles *ABE*, *GCB*, *HDC* and *FED* are respectively similar to triangles *AGF*, *GHA*, *HFG* and *FAH*. For any configuration of parallelogram linkage *EBCD*, quadrangle *AGHF* retains constant angles at its vertices. When link *1* turns about fixed axis *A*, selected as the centre of similarity, and one of the points, *G*, *H* or *F*, is traced along any arbitrary path, the other two points describe similar paths turned through constant angles. The mechanism has reversibility since any point, *A*, *G*, *H* or *F*, can be selected as the centre of similarity.

853

MULTIPLE-BAR PANTOGRAPH MECHANISM

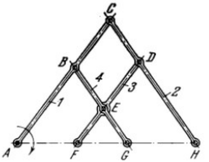
LW
P



The lengths of the links comply with the conditions: $\overline{EB} = \overline{DC}$ and $\overline{BC} = \overline{ED}$, i.e. figure *EBCD* is a parallelogram linkage. Rigid triangles *ABE*, *GCB* and *HDC* are respectively similar to triangles *AGF*, *GHA* and *HFG*. For any configuration of parallelogram linkage *EBCD*, triangle *AGH* retains constant angles at its vertices. When link *1* turns about fixed axis *A*, selected as the centre of similarity, and one of the points, *G*, *H* or *F*, is traced along any arbitrary path, the other two points describe similar paths turned through constant angles. The mechanism has reversibility since any point, *A*, *G*, *H* or *F*, can be selected as the centre of similarity.

854 MULTIPLE-BAR PANTOGRAPH MECHANISM

LW
P

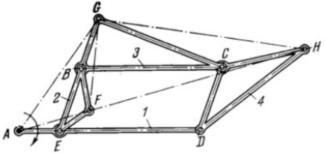


The lengths of the links comply with the conditions: $\overline{BC} = \overline{ED}$ and $\overline{EB} = \overline{DC}$, i.e. figure *EBCD* is a parallelogram linkage. An additional conditions is that $\overline{AC} : \overline{CH} = \overline{FD} : \overline{DH} = \overline{AB} : \overline{BG}$. For any configuration of parallelogram linkage *EBCD*, points *A*, *F*, *G* and *H* lie on a single straight line. When link *1* turns about fixed axis *A*, selected as the centre of similarity, and one of the points, *G*, *H* or *F*, is traced along any arbitrary path, the other two points describe similar paths. The mechanism has reversibility since any point, *A*, *F*, *G* or *H*, can be selected as the centre of similarity.

855 MULTIPLE-BAR PANTOGRAPH MECHANISM

LW

P



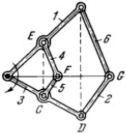
The lengths of the links comply with the conditions: $\overline{EB} = \overline{DC}$ and $\overline{BC} = \overline{ED}$, i.e. figure $EBCD$ is a parallelogram linkage. Rigid triangles FBE, GCB and HCD are respectively similar to triangles FGA, GHF and HGA. For any configuration of parallelogram linkage $EBCD$, triangle AGH retains constant angles at its vertices. When link 1 turns about fixed axis A, selected as the centre of similarity, and one of the points, G, H or F, is traced along any arbitrary path, the other two points describe similar paths turned through constant angles. The mechanism has reversibility since any point, A, G, H or F, can be selected as the centre of similarity.

856

MULTIPLE-BAR PANTOGRAPH MECHANISM ACCOMPLISHING TRANSLATION OF TWO STRAIGHT LINES

LW

P



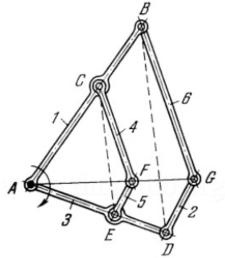
The lengths of the links comply with the conditions: $\overline{AB} : \overline{AE} = \overline{BG} : \overline{EF} = \overline{AD} : \overline{AC} = \overline{DG} : \overline{CF}$, $\overline{AC}^2 + \overline{EF}^2 = \overline{AE}^2 + \overline{CF}^2$ and $\overline{AB}^2 + \overline{DG}^2 = \overline{AD}^2 + \overline{BG}^2$. For any configuration of the mechanism, points *A*, *F* and *G* lie on a single straight line. When link *1* turns about fixed axis *A*, selected as the centre of similarity, and one of the points *F* or *G*, is traced along any arbitrary path, the other point describes a similar path. The mechanism has reversibility since any point, *A*, *G* or *F*, can be selected as the centre of similarity. The pantograph also accomplishes translational motion of two parallel straight lines, *EC* and *BD*. These lines are always perpendicular to line *AFG*.

857

MULTIPLE-BAR PANTOGRAPH MECHANISM ACCOMPLISHING TRANSLATION OF PARALLEL STRAIGHT LINES

LW

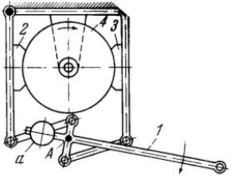
P



The lengths of the links comply with the condition: $\overline{AB} : \overline{AC} = \overline{BG} : \overline{CF} = \overline{AD} : \overline{AE} = \overline{DG} : \overline{EF}$. For any configuration of the mechanism, points A, F and G lie on a single straight line. When link 1 turns about fixed axis A, selected as the centre of similarity, and one of the points, F or G, is traced along any arbitrary path, the other point describes a similar path. The mechanism has reversibility since any point, A, F or G, can be selected as the centre of similarity. The pantograph also accomplishes translational motion of two parallel straight lines, CE and BD.

858 MULTIPLE-BAR MECHANISM OF A BLOCK BRAKE

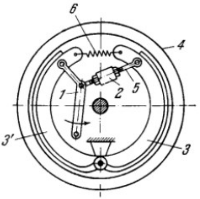
LW
Br



When lever *1* is turned clockwise about fixed axis *A*, shoes *2* and *3* are pressed against the rim of wheel *4*, thereby applying the brake. The brake counterbalances the load on the shaft. Weight *a* tends to retract shoes *2* and *3* from the rim of wheel *4*

859 MULTIPLE-BAR MECHANISM OF A SHOE BRAKE

LW
Br

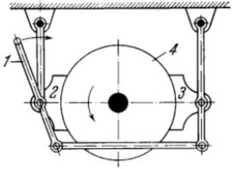


Shoes *3* and *3′* are pressed against the rim of wheel *4* by turning lever *1* counterclockwise. Nut *2* serves to adjust the length of tie-rod *5*. Spring *6* tends to retract shoes *3* and *3′* from the rim of wheel *4*.

860

MULTIPLE-BAR MECHANISM OF A BLOCK BRAKE

LW
Br



When lever *1* is turned clockwise, shoes *2* and *3* are pressed against the rim of wheel *4*, thereby braking the wheel.

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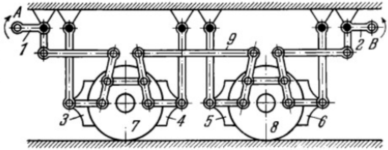
861

MULTIPLE-BAR MECHANISM OF A COMPLEX BLOCK BRAKE

LW
Br



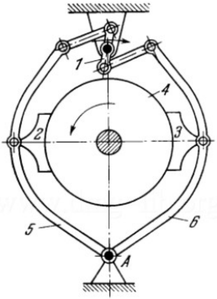
The mechanism consists of two kinematic chains with links of equal lengths by means of which shoes *3* and *4*, and *5* and *6*, are applied to wheels *7* and *8*. These chains are interconnected by link *9*. When levers *1* and *2* are turned, the first clockwise and the second counterclockwise, shoes *3*, *4*, *5* and *6* are pressed against the rims of wheels *7* and *8*, thereby braking the wheels.

862

MULTIPLE-BAR MECHANISM OF A BLOCK BRAKE

LW

Br

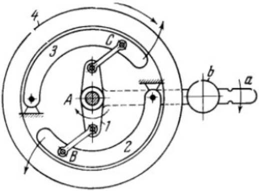


Links *5* and *6* are designed as curvilinear levers that turn about fixed axis *A*. When lever *1* is turned clockwise, shoes *2* and *3* are pressed against the rim of wheel *4*, thereby braking the wheel.

863

MULTIPLE-BAR MECHANISM OF A SHOE BRAKE

LW
Br



Link *1* has handle *a*. When handle *a* is turned clockwise, shoes *2* and *3*, connected to link *1* by links at points *B* and *C*, are pressed against the rim of wheel *4*, thereby braking the wheel. Weight *b* can be adjusted along handle *a* and clamped in various positions.

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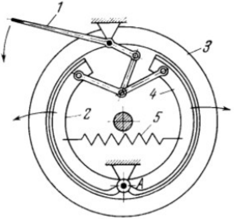
864

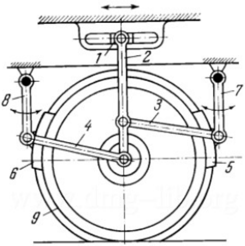
MULTIPLE-BAR MECHANISM OF A SHOE BRAKE

LW
Br



When handle *1* is turned counterclockwise, shoes *2* and *4*, turning about fixed axis *A*, are pressed against the rim of wheel *3*, thereby braking the wheel. Spring *5* retracts the shoes when lever *1* is released.

MULTIPLE-BAR MECHANISM OF A DOUBLE RAILWAY BRAKE

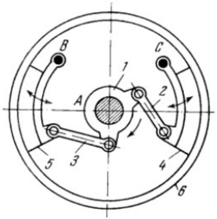


When sliding member *1* slides to the left, links *2*, *3* and *7*, and *4* and *8* press shoes *5* and *6* against the rim of wheel *9*, thereby braking the wheel.

866

MULTIPLE-BAR MECHANISM OF A SHOE BRAKE

LW
Br

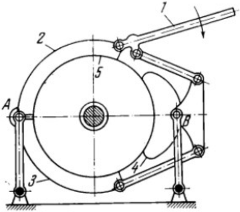


When link *1* is turned clockwise about fixed axis *A*, links *2* and *3* turn shoes *4* and *5* about fixed axes *C* and *B* so that the shoes are pressed against the rim of wheel *6*, thereby braking the wheel. Axes *B* and *C* are rigidly secured to axis *A*.

867

MULTIPLE-BAR MECHANISM OF A TRIPLE BLOCK BRAKE

LW
Br

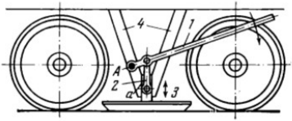


Shoes *2* and *3* turn about axes passing through point *A*. Shoe *4* turns about an axis passing through point *B*. When lever *1* is turned clockwise, shoes *2*, *3* and *4* are pressed against the rim of wheel *5*, thereby braking the wheel.

868

MULTIPLE-BAR MECHANISM OF A TRACK BRAKE

LW
Br



Shoe *3* is rigidly secured to sliding member *a* which slides in fixed guide *4*. When lever *1* is turned clockwise, shoe *3* is pressed against the rail, thereby braking the car.

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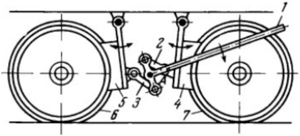
869

MULTIPLE-BAR MECHANISM OF A WHEEL BRAKE

LW
Br

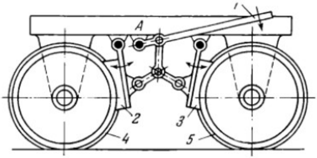


When lever *1* is turned clockwise about fixed axis *A*, links *2* and *3* press shoes *4* and *5* against the rims of wheels *7* and *6*, thereby braking the car.

870

MULTIPLE-BAR MECHANISM OF A WHEEL BRAKE

LW
Br



When lever *1* is turned clockwise about fixed axis *A*, shoes *2* and *3* are pressed against the rims of wheels *4* and *5*, thereby braking the car.

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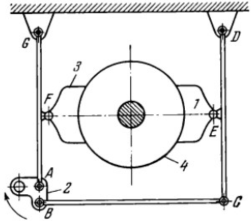
871

MULTIPLE-BAR MECHANISM OF A BLOCK BRAKE

LW
Br

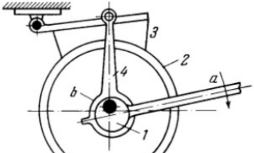


Shoes *1* and *3* are pressed against pulley *4* for braking by means of a five-bar linkage *ABCDG* when link *2* is turned clockwise. Shoes *1* and *3* turn freely about axes *E* and *F*, enabling them to become properly aligned with the pulley surface.

872

LEVER-ECCENTRIC MECHANISM OF A BLOCK BRAKE

LW
Br

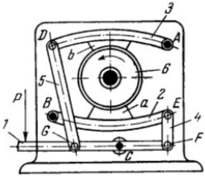


Lever *a* is rigidly secured to eccentric *1*. Link *4* has collar *b* encircling eccentric *1*. When eccentric *1* is turned clockwise by lever *a*, shoe *3* is pressed against the rim of wheel *2*, thereby braking the wheel.

873

MULTIPLE-BAR MECHANISM OF A DOUBLE BLOCK BRAKE

LW
Br

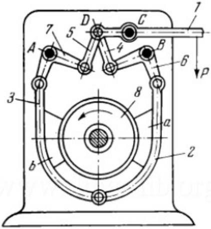


Levers *2* and *3*, turning about fixed axes *B* and *A*, are connected by turning pairs *E* and *D* to links *4* and *5*. Lever *1* turns about fixed axis *C* and is connected by turning pairs *F* and *G* to links *4* and *5*. When force *P* is applied to lever *1*, shoes *a* and *b*, mounted on levers *2* and *3*, are pressed by means of links *4* and *5* against the rim of rotating pulley *6*, thereby braking the pulley.

874

MULTIPLE-BAR MECHANISM OF A DOUBLE BLOCK BRAKE

LW
Br



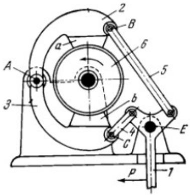
Symmetrically arranged angle levers *7* and *6* turn about fixed axes *A* and *B*. These levers are turned by levers *5* and *4* which are of the same length and are connected by turning pairs *D* to lever *1*. When force *P* is applied to lever *1*, turning about fixed axis *C*, motion is transmitted through levers *4*, *5*, *6* and *7* to shoes *a* and *b* mounted on levers *2* and *3*. Shoes *a* and *b* are pressed with equal force against the rim of rotating pulley *8*, thereby braking the pulley.

875

MULTIPLE-BAR MECHANISM OF A DOUBLE BLOCK BRAKE

LW

Br



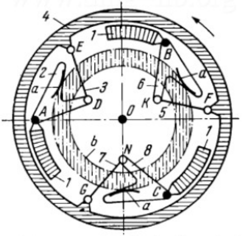
Levers 2 and 3 turn about common fixed axis A. Links 4 and 5 are connected by turning pairs C and B to links 3 and 2. They are also connected by turning pairs to lever 1 which turns about fixed axis E. When force P is applied to lever 1, motion is transmitted through links 5 and 4 to shoes a and b mounted on levers 2 and 3. Shoes a and b are pressed against the rim of rotating pulley 6, thereby braking the pulley.

876

MULTIPLE-BAR BRAKE MECHANISM

LW

Br

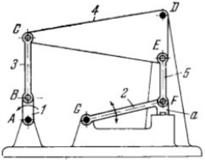


Links 3, 5 and 7 are connected by turning pairs E, F and G to housing 4 which rotates about fixed axis O. Links 2, 6 and 8, with braking members a, turn about fixed axes A, B and C which belong to fixed links 1. Links 2, 6 and 8 are connected by turning pairs D, K and N to links 3, 5 and 7. When housing 4 is turned counterclockwise with respect to links 1, members a are pressed against stationary body b, thereby braking the housing.

22. HAMMER, PRESS, AND DIE MECHANISMS
(877 and 878)

877 SIX-BAR PRESS MECHANISM

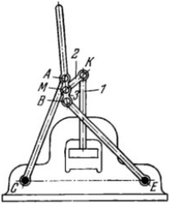
LW
HP



Link *5* is connected by turning pair *E* to rocker arm *4* of four-bar linkage *ABCD*. Rocker arm *2*, turning about fixed axis *G*, is connected by turning pair *F* to link *5* and carries punch member *a*. When crank *1* rotates, rocker arm *2* oscillates, performing a pressing action. In the end position in pressing, points *A*, *B* and *C* of links *1* and *3* and points *F*, *E* and *D* of links *5* and *4* lie on two parallel straight lines passing through points *A* and *D*. At this, the conditions: $\overline{AB} + \overline{BC} = \overline{FE} + \overline{ED}$ and $\overline{CD} = \overline{AF}$ are complied with, i.e. figure *ACDF* is a parallelogram linkage.

878 CHEBYSHEV MULTIPLE-BAR PRESS MECHANISM

LW
HP



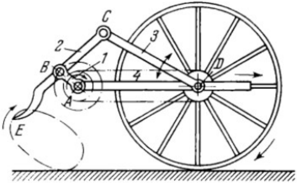
The lengths of the links comply with the conditions: $\overline{AC} = \overline{BE} = 1$, $\overline{CE} = 1.105$, $\overline{AM} = \overline{BM} = 0.19$ and $\overline{MK} = 0.211$. Connected to the Chebyshev symmetric four-bar linkage *CABE* is link *2* which transmits motion to link *1*. The driving link is connecting rod *3* whose complex motion is transformed into translational motion of link *1*.

23. MECHANISMS OF OTHER FUNCTIONAL DEVICES
(879 through 912)

879

FOUR-BAR MECHANISM OF A HAY-TEDDER

LW
FD

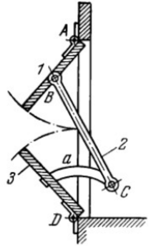


The hay-tedder mechanism consists of four-bar linkage *ABCD* mounted on frame *4*. When the wheel rolls to the right, crank *1* is rotated about axis *A* by means of a chain drive. Point *E* on the extension of link *2*, which is connected to link *3*, describes a path which is used for tedding (spreading newly cut grass) in hay-making.

880

FOUR-BAR MECHANISM FOR OPENING DOORS

LW
FD



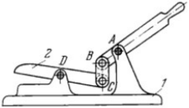
Door wings *1* and *3*, together with link *2*, form four-bar linkage *ABCD*. Wing *3* can be fastened at various positions along quadrant *a*. This enables it to be adjusted so that both door wings close together.

881

FOUR-BAR MECHANISM OF A HAND LEVER SHEAR

LW

FD



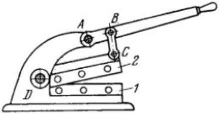
The mechanism consists of four-bar linkage *ABCD*. The stationary blade is rigidly secured to base *1* and the movable blade to link *2*.

882

FOUR-BAR MECHANISM OF A HAND LEVER SHEAR

LW

FD



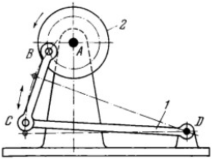
The mechanism consists of four-bar linkage *ABCD*. The stationary blade is rigidly secured to base *1* and the movable blade to link *2*.

883

FOUR-BAR MECHANISM OF A TREADLE DRIVE

LW

FD



The treadle drive mechanism consists of four-bar linkage *ABCD*. After being pressed down by the foot, treadle *1* is raised by the inertia of rotating flywheel *2*.

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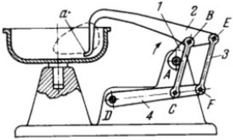
884

MULTIPLE-BAR MECHANISM OF A DOUGH-KNEADER

LW

FD

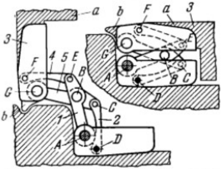


Link *2* with lug *a* is connected by turning pairs *B* and *E* to crank *1* of four-bar linkage *ABCD* and to link *3* which, in turn, is connected by turning pair *F* to rocker arm *4*. When crank *1* rotates about fixed axis *A*, points of lug *a* of the kneader describe complex connecting-rod curves that are used for the kneading process.

885

MULTIPLE-BAR MECHANISM OF AN AUTOMOBILE DOOR HINGE

LW
FD

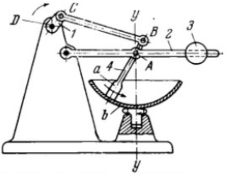


Rocker arms *1* and *2* of four-bar linkage *ABCD* turn about fixed axes *A* and *D* which belong to the automobile body. Link *3*, to which door *a* is rigidly secured, is connected by turning pairs *F* and *G* to link *4* and connecting rod *5*. Link *4* is connected by turning pair *E* to rocker arm *1*. In the open position of the door, the mechanism is indexed by projection *b* of link *3* which enters a corresponding groove in the body. The door is shown in the open position in the left-hand drawing and in the closed position in the right-hand one.

886

MULTIPLE-BAR MECHANISM OF A MIXER

LW
FD



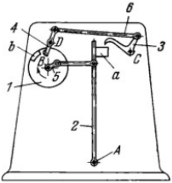
Rocker arm *4* of four-bar linkage *DCBA* turns about axis *A* and has paddle *a* at its end. When crank *1* rotates about fixed axis *D*, paddle *a* slides along the bottom of bowl *b*. The bowl bottom is spherical with the centre at point *A*. Lever *2* with weight *3* serve to hold paddle *a* against the bottom of bowl *b*. The bowl is rotated about vertical axis *y*-*y* by a drive which is not shown.

887

IVANOV AUTOMATIC MUTIPLE-BAR MECHANISM FOR CHANGING BOBBINS IN A LOOM

LW

FD



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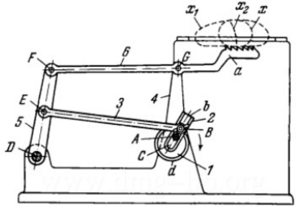
When disk *1* rotates together with crank *5*, secured to the disk, about fixed axis *B*, slay *2* oscillates about fixed axis *A*. To change the bobbin in shuttle *a* which moves together with slay *2*, angle lever *3* turns about fixed axis *C* so that it takes a new bobbin from the magazine (not shown in the drawing) and places it into the shuttle, pushing out the used bobbin. For this purpose, lug *b* on disk *1* engages lever *4* at definite times. Lever *4* turns about fixed axis *D* and transmits a turning motion, through intermediate link *6*, to lever *3* about axis *C*.

888

MULTIPLE-BAR MECHANISM FOR REGULATING THE STITCH LENGTH IN A SEWING MACHINE

LW

FD



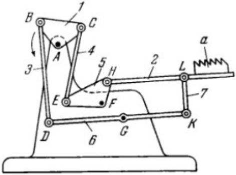
Circular eccentric *1*, rotating about fixed axis *A*, is connected by turning pair *B* to link *3*. Link *4* has collar *d* encircling eccentric *1*. Link *5*, turning about fixed axis *D*, is connected by turning pairs *E* and *F* to links *3* and *6*. Links *4* and *6* are connected by turning pair *G*. Eccentric *1* is rigidly secured to link *2* which has slot *b* along which pivot *B* can be adjusted and clamped. This changes length $\overline{AB}$. When eccentric *1* rotates, teeth *a* describe connecting-rod curve *x* when $\overline{AB} = \overline{AC}$, curve x_1 when $\overline{AB} > \overline{AC}$ and curve x_2 when $\overline{AB} = 0$. In the last case the stitch length equals zero.

889

MULTIPLE-BAR MECHANISM FOR THE CLOTH ADVANCER OF A SEWING MACHINE

LW

FD



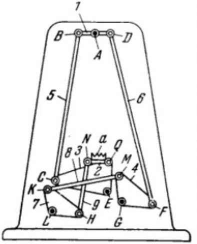
Connecting rods *3* and *4* are connected by turning pairs *B* and *C* to crank *1*, turning about fixed axis *A*, and by turning pairs *D* and *E* to rocker arms *6* and *5* which turn about fixed axes *G* and *F*. Link *2* is connected by turning pair *H* to rocker arm *5* and by turning pair *L* to link *7* which, in turn, is connected by turning pair *K* to rocker arm *6*. When crank *1* turns about axis *A*, serrated member ***a*** has a complex motion in which it grips and advances the cloth being sewn.

890

MULTIPLE-BAR MECHANISM FOR THE CLOTH ADVANCER OF A SEWING MACHINE

LW

FD



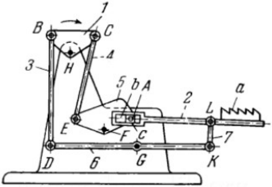
Connecting rods *5* and *6* are connected by turning pairs *B* and *D* to crank *1*, turning about fixed axis *A*, and by turning pairs *C* and *F* to rocker arms *3* and *4* which turn about fixed axes *E* and *G*. Connecting rod *8* is connected by turning pairs *M* and *K* to rocker arm *4* and to rocker arm *7* which turns about fixed axis *L*. Link *9* is connected by turning pairs *H* and *N* to rocker arm *7* and to link *2* which, in turn, is connected by turning pair *Q* to rocker arm *3*. When crank *1* turns about axis *A*, serrated member ***a***, mounted on link *2*, has a complex motion in which it grips and advances the cloth being sewn.

891

MULTIPLE-BAR MECHANISM FOR THE CLOTH ADVANCER OF A SEWING MACHINE

LW

FD

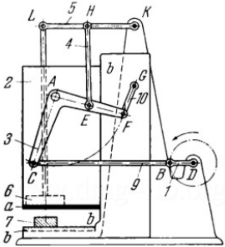


Connecting rods *3* and *4* are connected by turning pairs *B* and *C* to crank *1*, turning about fixed axis *H*, and by turning pairs *D* and *E* to rocker arms *6* and *5* which turn about fixed axes *G* and *F*. Link *2* is connected by turning pair *A* to rocker arm *5* and by turning pair *L* to link *7* which, in turn, is connected by turning pair *K* to rocker arm *6*. Link *2* has slotted end *b* sliding along sliding member *c* which turns about axis *A*. Sliding member *c* can be set at various positions along slotted end *b* and clamped. This changes the length $\overline{AL}$ of link *2*, thereby regulating the stroke length of member *a*. When crank *1* turns about axis *H*, serrated member *a*, mounted on link *2*, has a complex motion in which it grips and advances the cloth being sewn.

892

MULTIPLE-BAR MECHANISM OF A SHEAR

LW
FD



Crank *1* rotates about fixed axis *D*. Link *9* is connected by turning pairs *B* and *C* to crank *1* and to link *3* which, in turn, is connected by turning pair *A* to ram *2* carrying knife *a*. Ram *2* slides along vertical ways *b-b*. Link *3* is connected by turning pairs *E* and *F* to links *4* and *10*. Link *10* turns about fixed axis *G*. Link *4* is connected by turning pair *H* to rocker arm *5* which turns about fixed axis *K*. Suspended by turning pair *L* from rocker arm *5* is hold-down *6* which turns freely about axis *L*. When crank *1* rotates counterclockwise, ram *2* with upper knife *a* travel downward. Hold-down *6* also travels downward. Ram travel ceases when the hold-down reaches knife *a*. The stock is sheared by raising lower knife *b* upon further rotation of crank *1*.

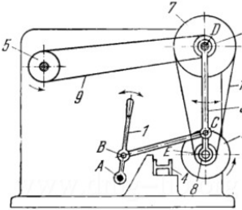
The mechanism for raising the lower knife is not shown.

893

MULTIPLE-BAR MECHANISM OF A VERTICAL PENDULUM BELT-DRIVE CROSS-CUT SAW

LW

FD

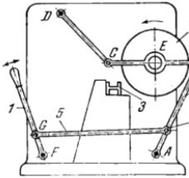


Lever *1* turns about fixed axis *A*. Circular saw *2* is mounted at point *E* of lever *3* in four-bar linkage *ABCD*. When lever *1* is shifted to the left, circular saw *2* is advanced to stock *4*. Saw *2* is driven by an electric motor through pulleys *5*, *6*, *7* and *8* and belts *9* and *10*. When lever *1* is shifted to the right, the saw is returned to its initial position.

894

MULTIPLE-BAR MECHANISM OF A PENDULUM CROSS-CUT SAW

LW
FD

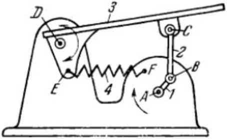


Circular saw *2*, driven by an electric motor about axis *E*, is mounted on connecting rod *4* of four-bar linkage *ABCD*. Lever *1* turns about fixed axis *F*. Link *5* is connected by turning pairs *G* and *H* to links *1* and *6*. When lever *1* is shifted to the left, circular saw *2* is advanced to stock *3*. When lever *1* is shifted to the right saw *2* is returned to its initial position.

895

FOUR-BAR MECHANISM FOR THE TILTING TABLE OF A ROLLING MILL STAND

LW
FD



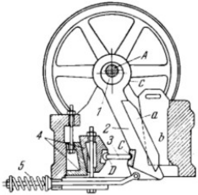
Crank *1* turns about fixed axis *A*. Link *2* is connected by turning pairs *B* and *C* to crank *1* and light-weight tilting table *3* of the roll stand in a rolling mill. The table turns about fixed axis *D*. Spring *4* is secured at its end *E* to the table and at end *F* to the fixed base. The spring serves for the dynamic counterbalancing of table *3*.

896

ECCENTRIC-TYPE MULTIPLE-BAR MECHANISM OF A STONE CRUSHER

LW

FD



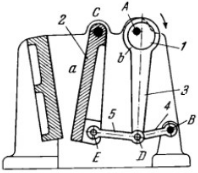
Connecting rod *2* has collar *c* encircling eccentric *1* which rotates about fixed axis *A*. Rocker arm *3* is designed as a member with ball-shaped ends which fit into spherical recesses *C* and *D* in connecting rod *2* and in the fixed link. Eccentric *1* drives connecting rod *2* which carries crushing surface *a*. This surface has a simultaneous crushing and abrading action on the material placed in space *b* between the jaws. The fineness of crushing is regulated by wedge mechanism *4* which varies the position of point *D*. Spring *5* absorbs dynamic forces (shocks) in the operation of the mechanism.

897

MULTIPLE-BAR MECHANISM OF A STONE CRUSHER

LW

FD

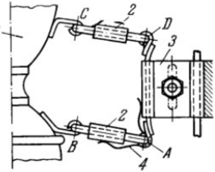


Circular eccentric *1* rotates about fixed axis *A*. Link *3* has collar *b* encircling eccentric *1*. Link *3* is connected by turning pairs *D* to links *4* and *5*. Link *5* is connected by turning pair *E* to crusher jaw *2* which turns about fixed axis *C*. When eccentric *1* rotates about axis *A*, jaw *2* oscillates and thereby crushes the material dumped into space *a* between the jaws.

898

FOUR-BAR MECHANISM OF A BICYCLE HEADLIGHT BRACKET

LW
FD



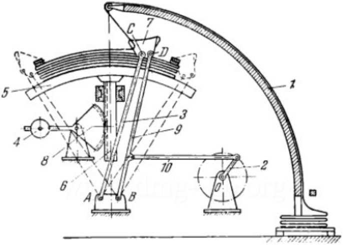
The lengths of the links comply with the conditions: $\overline{BA} = \overline{CD}$ and $\overline{AD} = \overline{BC}$. Headlight *1*, with members *2* and holder *3*, secured on the bicycle handlebars, forms parallelogram linkage *ABCD*. The headlight is held in the required position by flat spring *4* and holder *3*.

899

MULTIPLE-BAR MECHANISM OF A MEASURING MACHINE

LW

FD



The mechanism is based on four-bar double-swing linkage *ACDB* which is driven by crank *2* through intermediate link *10*. When crank *2* rotates about fixed axis *O*, levers *3* and *9* oscillate about fixed axes *A* and *B*. The ribbon slides along guide *1*. Then it passes through component *7* of link *CD* and is laid on platform *5*. By means of weight *4*, mounted on the extension of segment gear *8* which meshes with rack *6*, platform *5* can be set at the required height.

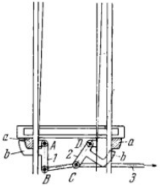
900

MULTIPLE-BAR MECHANISM OF A RAILWAY SWITCH

LW

FD

Links *1* and *2* of four-bar linkage *ABCD* have hooks *b*. Hooks *b* engage block members *a* and thereby lock the whole mechanism. To operate the switch it is sufficient to pull link *3*, which is connected by turning pair *C* to link *2*, to the right.



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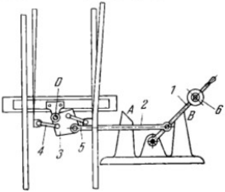
901

MULTIPLE-BAR MECHANISM OF A RAILWAY SWITCH

LW

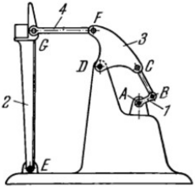
FD



Link *2* connects lever *1* to link *3*. To set the switch, lever *1* is shifted from support *B* to support *A*. At this, link *2* turns link *3* about fixed axis *O* and tie-rods *4* and *5* operate the switch. Weight *6* locks lever *1*, holding the switch in either position. Lever *1*, link *2* and the base have been conditionally turned through 90° in the drawing.

902 MULTIPLE-BAR SLAY MECHANISM

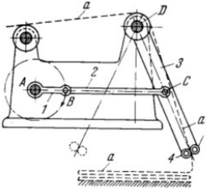
LW
FD



The slay mechanism consists of four-bar linkage *ABCD* in which rocker arm *3* turns about fixed axis *D*. Link *4* is connected by turning pair *F* to rocker arm *3* and by turning pair *G* to slay *2*. When crank *1* is rotated about fixed axis *A*, slay *2* oscillates about fixed axis *E*.

903 FOUR-BAR CLOTH FOLDER MECHANISM

LW
FD

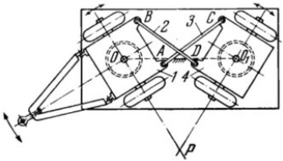


Rocker arm *3* of four-bar linkage *ABCD* carries two rollers *4* between which cloth *a* being folded is drawn. Two layers of cloth are laid to each revolution of crank *1*.

904

CROSSED-CRANK MECHANISM FOR A WAGON STEERING GEAR

LW
FD



The lengths of the links comply with the conditions: $\overline{AB} = \overline{CD}$ and $\overline{BD} = \overline{AC}$. Thus, links *1*, *2*, *3* and *4* form crossed-crank linkage *ABDC*. When link *1* is turned about fixed axis *O*, link *4* is turned in the opposite direction about fixed axis O_1. The whole wagon turns about point *P* which is the instantaneous centre of rotation.

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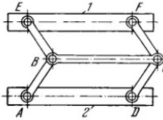
905

MULTIPLE-BAR TRANSLATOR MECHANISM FOR PARALLEL RULES

LW
FD

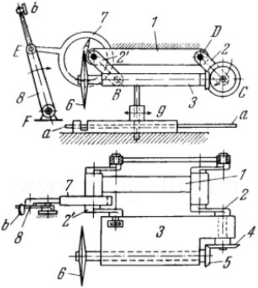


The lengths of the links comply with the conditions: $\overline{AB} = \overline{DC}$, $\overline{BE} = \overline{CF}$ and $\overline{EF} = \overline{BC} = \overline{AD}$. In any position of rule *2*, the edge of rule *1* is always parallel to the edge of rule *2*.

906

MULTIPLE-BAR PARALLELOGRAM MECHANISM FOR CUTTING OFF CIGARETTES

LW
FD



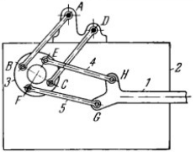
The lengths of the links comply with the conditions: $\overline{AB} = \overline{DC}$ and $\overline{AD} = \overline{BC}$. When cranks *2* and *2'* turn about fixed axes *D* and *A*, link *3*, carrying rotary knife *6* descends and enters a slot of carriage *9*, thereby cutting off a cigarette from string *a-a*. Rotation is transmitted to knife *6* through bevel gears *4* and *5*. Grindstone *b* is mounted on lever *8* which is connected by turning pair *E* to eccentric *7*. Eccentric *7* is rigidly secured to crank *2'*. In its upper position, rotating knife *6* contacts grindstone *b* and is sharpened.

907

TRANSLATOR MECHANISM FOR A DRAFTING MACHINE

LW

FD



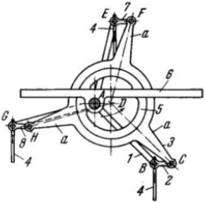
The lengths of the links comply with the conditions: $\overline{AB} = \overline{DC}$, $\overline{AD} = \overline{BC}$, $\overline{EH} = \overline{FG}$ and $\overline{FE} = \overline{GH}$. The mechanism has two degrees of freedom so that scale *1*, in its translational motion, can take any position on board *2*. At this, all points of scale *1* describe identical plane paths. If ring member *3* is fixed in any required position, scale *1* has translational motion and its points describe circles of a radius equal to $\overline{EH} = \overline{FG}$. This enables parallel lines to be drawn in the required direction.

908

MULTIPLE-BAR PARALLELOGRAM MECHANISM OF A HAY-TEDDER

LW

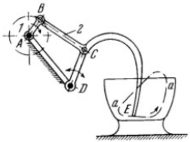
FD



The lengths of the links comply with the conditions: $\overline{AB} = \overline{DC} = \overline{AE} = \overline{DF} = \overline{AG} = \overline{DH}$ and $\overline{BC} = \overline{EF} = \overline{GH} = \overline{AD}$. Link *3* has three lugs *a* and encircles fixed circular eccentric *5* which is secured rigidly to frame *6*. Rigidly secured to links *2*, *7* and *8* are pins *4* which have a circular translational motion.

909 FOUR-BAR MECHANISM OF A DOUGH-KNEADER

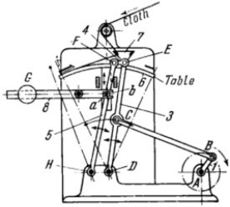
LW
FD



The kneader mechanism consists of four-bar linkage *ABCD*. When crank *1* turns about fixed axis *A*, point *E* of member *2* travels in the dough bowl along path *a-a*. The bowl rotates uniformly about its vertical axis by means of a mechanism not shown in the drawing.

910 SIX-BAR MECHANISM OF A CLOTH FOLDER

LW
FD

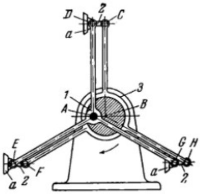


A two-bar linkage, consisting of links *4* and *5*, is connected by turning pairs *E* and *H* to four-bar linkage *ABCD*. Grip *7* is rigidly secured to link *4* by means of which it folds the cloth on segment *6*. The cloth is held on the segment by means of lever *8* having weight *G* at one end and fork *a* at the other. Fork *a* engages pin *b* of link *5*. The cloth is fed to the segment by a special mechanism which is not shown.

911

MULTIPLE-BAR PADDLE-WHEEL MECHANISM

LW
FD

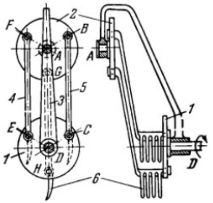


The lengths of the links comply with the conditions: $\overline{AD} = \overline{BC} = \overline{AE} = \overline{BF} = \overline{AG} = \overline{BH}$ and $\overline{DC} = \overline{EF} = \overline{GH} = \overline{AB}$. When triple crank *1* rotates, the axes of links *2* remain parallel to the line of centres *AB* and are therefore horizontal during travel. The mechanism is based on parallelogram linkage *ABCD* in which turning pair *B* is designed as a fixed disk encircled by collar *3*. Paddles *a* are mounted on links *2*.

912

TRIPLE PARALLELOGRAM MECHANISM OF A POTATO DIGGER

LW
FD



The lengths of the links comply with the conditions: $\overline{AB} = \overline{DC}$, $\overline{AF} = \overline{DE}$, $\overline{AG} = \overline{DH}$ and $\overline{AD} = \overline{BC} = \overline{FE} = \overline{GH}$. Links *1* and *2* rotate about fixed axes *D* and *A*. Connected to these disks by turning pairs are links *3*, *4* and *5* which form parallelogram linkages together with the disks. Digging members *6* are rigidly secured to links *3*, *4* and *5*. When link *1* rotates the mechanism holds the digging members in the vertical position.

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